COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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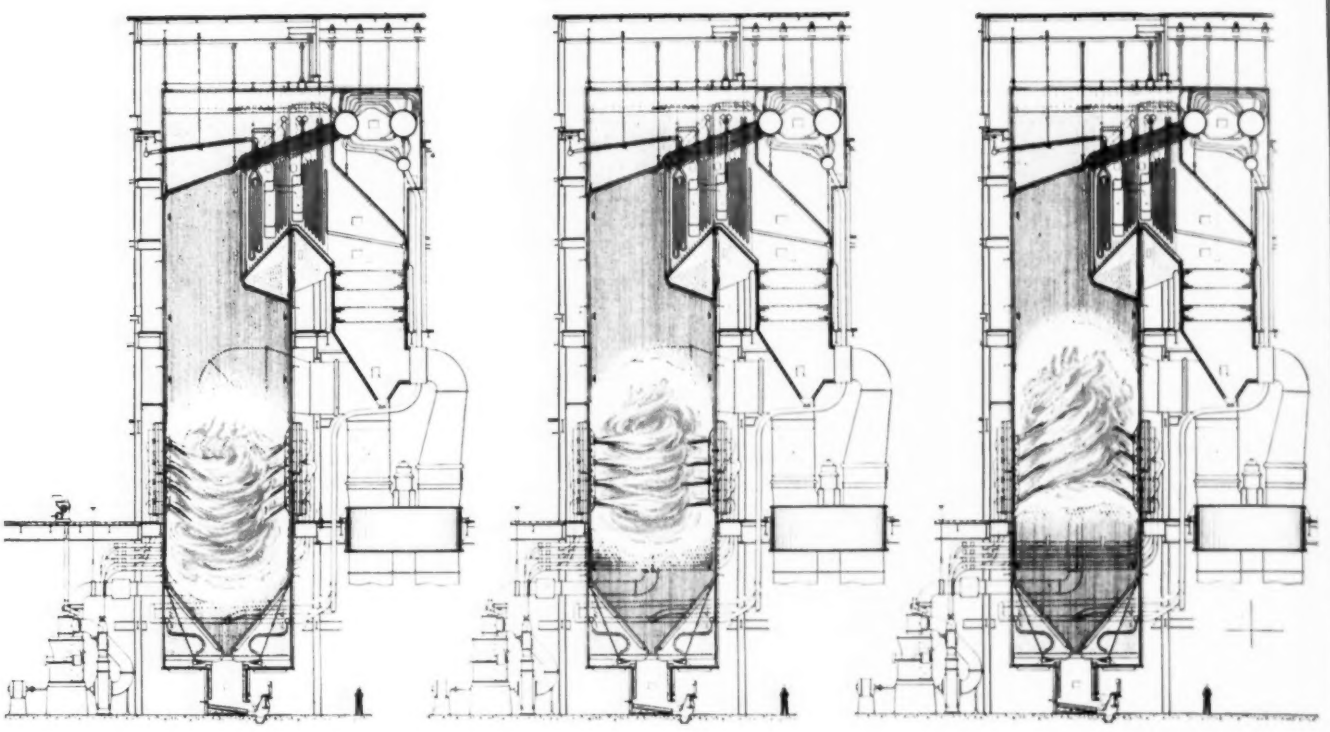
Boiler room of Perfection Stove Co., see p. 43

Chemical Recovery and By-product Steam in Finland

Automatic Sequential Soot Blowers—Steam vs. Air Blowing

Reducing Cost of Steam in Coal-Fired Boiler Plants



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   - ***(b) Minimum use of desuperheating spray.***
   - ***(c) Use of wide variety of coals.***
   - ***(d) Accurate proportioning of superheater and reheater surfaces.***
   - ***(e) Lower air heater maintenance.***
2. Substantial control over slagging conditions which results in:
   - ***(a) More uniform furnace conditions.***
   - ***(b) Better heat absorption.***
   - ***(c) Minimum use of soot blowers.***

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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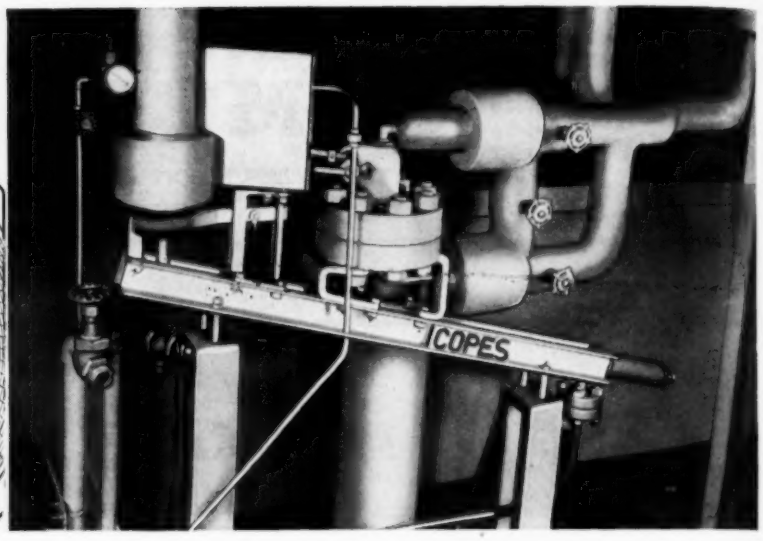

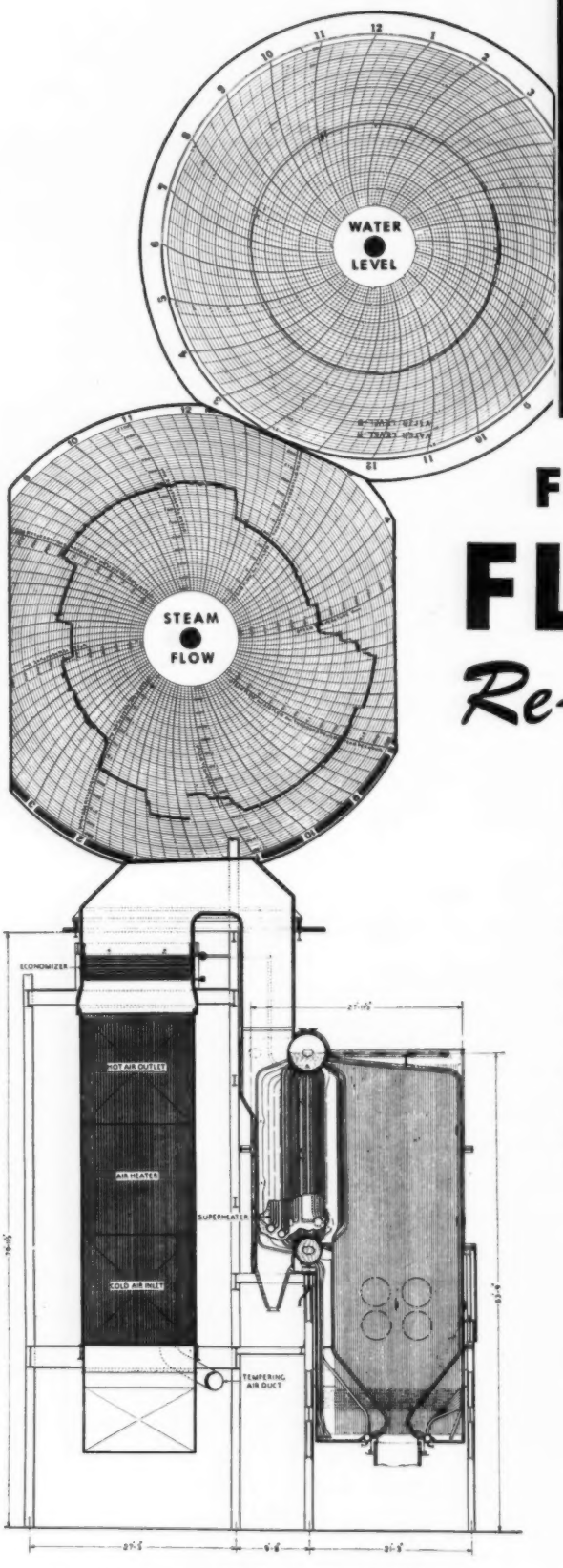

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Editorials

Material Controls vs. Design Trends

Despite a predicted increase in steel-making capacity of some sixteen per cent by 1954, the situation, as dictated by defense production requirements, will probably undergo further changes within the next few months and leave its imprint on numerous industries. This is inevitable as government controls crystallize.

That it will affect the timetable of scheduled utility expansion is apparent, but to what extent is as yet uncertain. Moreover, it is likely to influence certain design features, such as more extensive employment of semi-outdoor plant construction to conserve structural steel, and in many cases the use of substitutes for metal boiler casings to ease the demand for plate. Also, the recent placing of orders for a number of large, very high-pressure controlled-circulation steam generating units will effect a substantial saving in steel tonnage per unit of capacity, due to the small-diameter, thin-walled tubes which characterize such designs. In fact, these units appear to presage a trend that for several reasons seems to fit well into the requirements and practices of the times.

It is obvious that whatever changes in power plant design may be dictated by current conditions, a balance must be maintained between the availabilities of materials and labor.

Present indications are that with electric utility capacity already greatly expanded, and special provisions having been made by the Government for capacity to handle the exceptionally large requirements of the atomic energy program, there should be little or no shortage of power unless more drastic curtailment of power plant construction is put into effect than is now apparent.

The Midwest Power Conference

Elsewhere in this issue appears the program of the Thirteenth Midwest Power Conference which is to be held in Chicago during the first week of April. From a modest beginning this annual conference has grown, under the original sponsorship, to its present scope and prestige, and many regard it the outstanding meeting in the power field. A perusal of the program will confirm this. Although the annual and regional meetings of several engineering societies often include power sessions and symposiums of utmost importance, their programs are usually diluted with a vast variety of papers on subjects of little or no interest to power men. Not so, however, with the Midwest Conference, which deals wholly with power matters and thus reflects the importance of this field.

The designation "Midwest" was derived largely from the location in which it is held and from its sponsorship by a group of midwestern universities and the local sections of several national engineering societies; but in recent years its programs have taken on a nation-wide aspect and, more and more, the attendance has become representative of the whole country. It is anticipated that attendance at the forthcoming conference, despite demands of the present emergency, will exceed that of last year.

Steam Plant Preparedness

The industrial steam plant can make a major contribution to the defense mobilization effort if it is properly prepared. It is a generally accepted fact that an adequate and dependable supply of steam is essential to assure continuous industrial production.

In many plants it may be desirable to make a survey of power and steam facilities with a view to rectifying weak spots. One of the first things that comes to mind is the matter of fuels. Is the plant equipped to burn more than one type of fuel? What plans are there for plant operation in the event of shortages or curtailment in supply of the fuel now being burned? Are fuel storage facilities adequate? Or it might be asked, what provisions are being made to replace or revamp obsolete equipment? These are but a few of the questions that arise as one considers the state of steam plant preparedness.

As the defense mobilization effort steps up in intensity, many industrial power plants will be forced to carry greater sustained peak loads than ever before. To meet these demands it may be necessary to alter maintenance schedules and to carry out some procedures without the usual outages for overhaul and repairs. This will take careful planning on the part of those responsible for industrial power plant operation. In view of the manpower situation and the possibility that it may become more critical, the potential loss of skilled operators must also be faced. Steps should be taken to train replacements and to intensify their experience so that they are capable of meeting emergencies.

Industrial steam plants successfully met the demands of World War II. With that record of accomplishment and an awareness of problems that must be faced, they should be prepared for the future.

Chemical Recovery and By-product Steam in Finland

By V. P. Owens*

An important part of the industrial economy of Finland is the pulp and paper industry. This article describes and illustrates an American-built chemical recovery unit which has been in operation since September 1949, at the Kotka Mill of the Enso-Gutzeit Company. The relationship of the black liquor cycle to recovery unit operation is discussed, along with auxiliary equipment and controls.

IN terms of timber resources Finland is the richest country in Europe. With a climate favorable for the growth of pine and spruce and an abundance of natural transport facilities, this northern country is in an opportune position to have a large pulp and timber industry. The pine trees of Finland grow with a tall straight trunk having few knots and are therefore well adapted to the saw-mill industry. Spruce provides raw material for the paper and pulp industries, while birch is widely used for making plywood.

The most important domestic fuels of Finland are wood or wood refuse and peat. By far the greatest part of the wood refuse is used as fuel by the woodworking industry. In proportion to its area Finland has some of the largest peat deposits in the world, but thus far not much peat has been consumed as fuel because of its inability to compete economically with other fuels.

The electric energy supply in Finland is chiefly based on the utilization of water power. In 1948, hydro power was the means of generating 66 per cent of the energy; back-pressure steam turbines produced 14 per cent, and condensing steam turbines the remaining 20 per cent. The significance of the timber industry may be better understood when it is realized that in 1949 its consumption of electric energy was estimated to be 49 per cent of the national total.

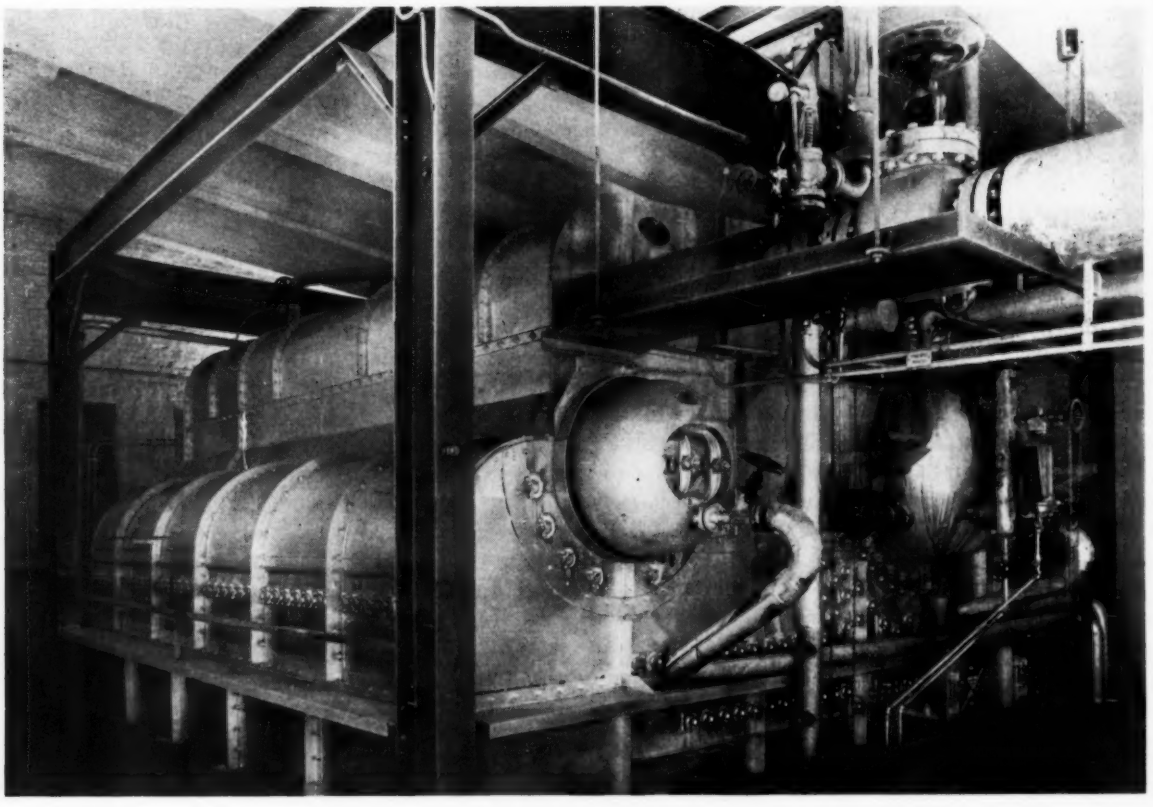


Fig. 1—Arrangement of upper steam drums

One of the most important organizations in the timber industry in Finland is the Enso-Gutzeit Company. Founded in 1872, the company has grown to the point that it now employs 14,000 persons throughout the year and as many as 20,000 during the height of the timber-felling season. Among the products of the company are sulfate, sulfite and mechanical pulp; paper; laminated fiber and corrugated board; sawed and planed goods; plywood; spools and bobbins; and chemicals.

* Paper Mill Equipment Dept., Combustion Engineering-Superheater, Inc.

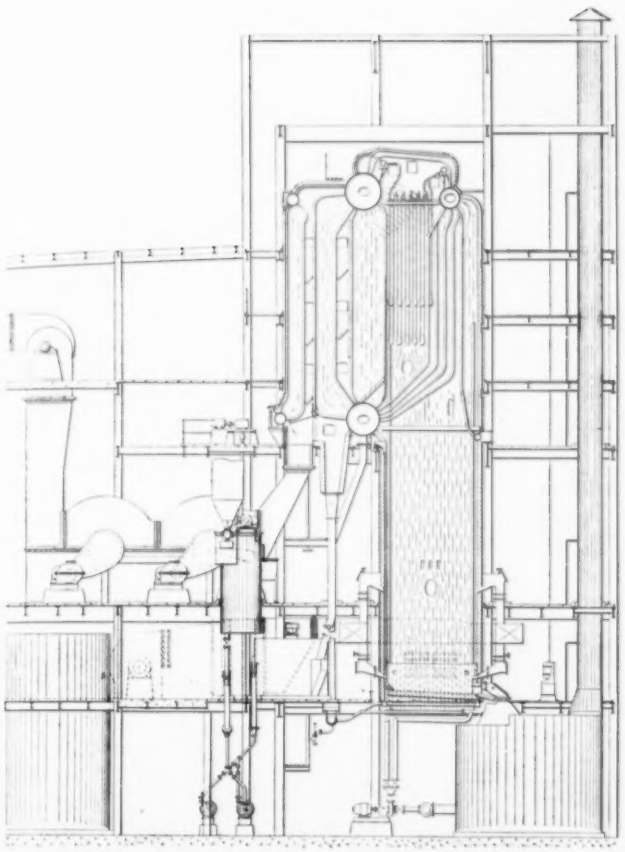


Fig. 2—Section through chemical recovery unit

Kotka Plant

Kotka, one of the principal plants of Enso-Gutzeit, is located on the Gulf of Finland about 100 miles east of Helsinki. It consists of a sulfate mill, a by-product mill, three saw mills, a prefabricated-house factory, and a machine shop.

In 1946, Pentti Halle, at that time general superintendent of the Kotka sulfate pulp mill, visited the United States. During his stay of several months he made a thorough investigation of modern equipment for pulp and paper mills, including chemical recovery units. As a result of this study an order was placed in 1947 for a 200-ton Combustion Engineering spray-type chemical recovery unit which was placed in operation in September 1949. Plans were made to extend the activities of the Kotka mill to include paper making, and a Beloit paper machine is now on order. The Enso-Gutzeit Company also has a sulfate pulp and paper mill located at Kaukopää, 95 miles north of Kotka. A 300-ton spray-type chemical recovery unit of similar design is now being erected at this mill.

Chemical Recovery Unit

The following description is intended for the information of readers not familiar with the operation of the chemical recovery unit which serves the pulp mill in a dual capacity. It provides a means of recovering the spent chemical from the black liquor that results from the digesting process and also serves as a steam generating unit by burning out the organic matter that is present in the black liquor.

In the Kotka mill steam is generated by the chemical recovery unit at the rate of 88,000 lb per hr. Superheater outlet conditions are 455 psig and 685 F with an entering feedwater temperature of 150 F. This steam supplements that generated in boilers fired by waste wood and coal.

Black liquor is produced as a result of the digesting action of a hot caustic solution upon wood chips. After being separated from cellulose fiber in pulp washers, the black liquor has a water content of 80 to 85 per cent. Multiple effect evaporators are used to reduce the water content to approximately 50 per cent, after which the black liquor is pumped to a storage tank from which it is then transferred to the cascade evaporator of the chemical recovery unit. At the Kotka mill the chemical recovery unit is designed for firing high-density black liquor averaging 68 per cent solids. The following table is based on a laboratory analysis of black liquor fired during a test of the Kotka unit:

Heat value, Btu per lb	6970
Organic matter, per cent	71.6
Total alkali, Na_2O, per cent	25.7
Total carbon, per cent	41.0
Organic carbon, per cent	40.3
Total sulfur, per cent	3.64
Organic sulfur, per cent	1.91
Hydrogen, per cent	3.70
Na_2CO_3, per cent	6.11
Na_2S, per cent	3.54
NaOH, per cent	2.54
Na_2SO_3, per cent	1.73

The cascade evaporator performs the function of concentrating the liquor from 50 to 68 per cent solids as well as recovering heat and gas scrubbing. The tem-

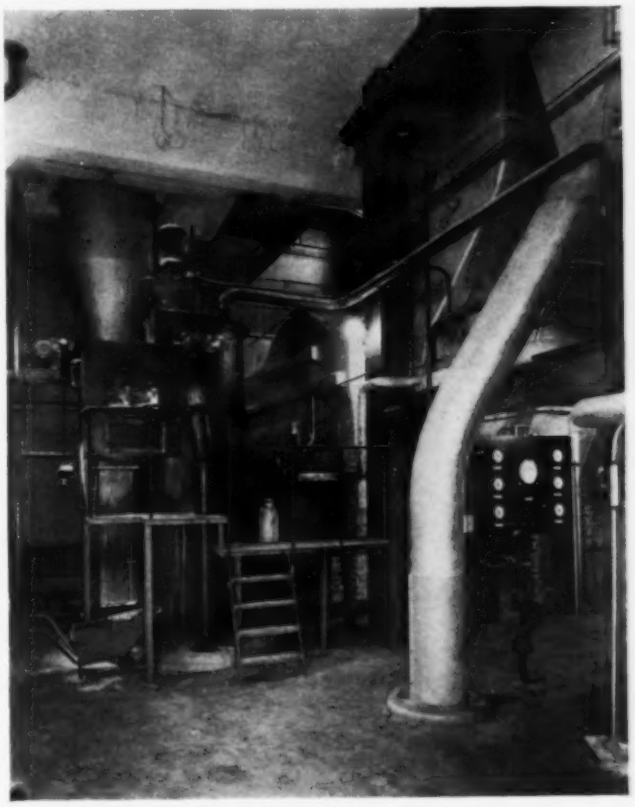


Fig. 3—Salt-cake mixing system and cascade evaporator

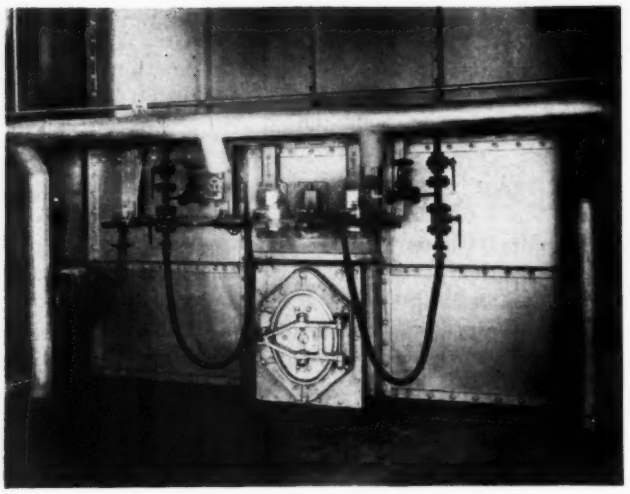


Fig. 4—Oscillating sprays for firing black liquor

perature of the gas entering the cascade is 610 F, which is reduced to 284 F when leaving. Heat from the flue gas evaporates the water from the black liquor and concentrates it to the 68 per cent solids previously mentioned. The large particles of chemicals entrained in the flue gas are deposited on the wetted plate surfaces of the cascade evaporator. Having been removed from the flue gas the particles are dissolved by the black liquor.

A bypass damper which is located at the bottom of the last boiler pass and the economizer pass serves to control the temperature of the gases entering the cascade evaporator. Evaporation in the cascade varies with the temperature of the entering gas. At times when the density of liquor entering the cascade is low, the temperature of gases entering the cascade is increased by opening the bypass damper. This increases the evaporation so that the normal high liquor density fired to the furnace can be maintained.

Heavy Black Liquor Cycle

The black liquor discharges from the cascade evaporator and flows to the salt-cake mixing tank by way of the flow box. In the salt-cake mixing tank the makeup chemical, sodium sulfate, is added by means of a calibrated screw feeder. This makeup chemical is required to replace the sodium salts and sulfur lost in the pulp mill processes and the material which escapes up the stack with the recovery unit flue gas. The salt-cake mixing system includes equipment for uniform feeding of screened makeup chemical, which is evenly mixed with the heavy black liquor in the salt-cake mixing tank.

The black liquor plus the mixed-in salt cake is passed through the black liquor heaters, of which there are two, one being installed before the black liquor pumps and the other after. Direct steam heaters have proved most desirable for this job. One heater raises the temperature to the optimum value for pumping, while the second heats the liquor to the proper temperature for drying and burning the liquor in the furnace. The level of the liquor in the cascade evaporator and the temperature of the black liquor at the sprays are uniformly maintained by vapor-actuated air-relay controllers.

The sprays consist of a breaker-plate and conical-shaped head which mechanically break up the liquor into the desired size of particle. There are two sprays at each end of the furnace. The sprays oscillate approximately every ten seconds through a small angle to provide a uniform distribution of dry fuel over the hearth area. The liquor dries in suspension, and the dry fuel falls to the hearth where the residual carbon

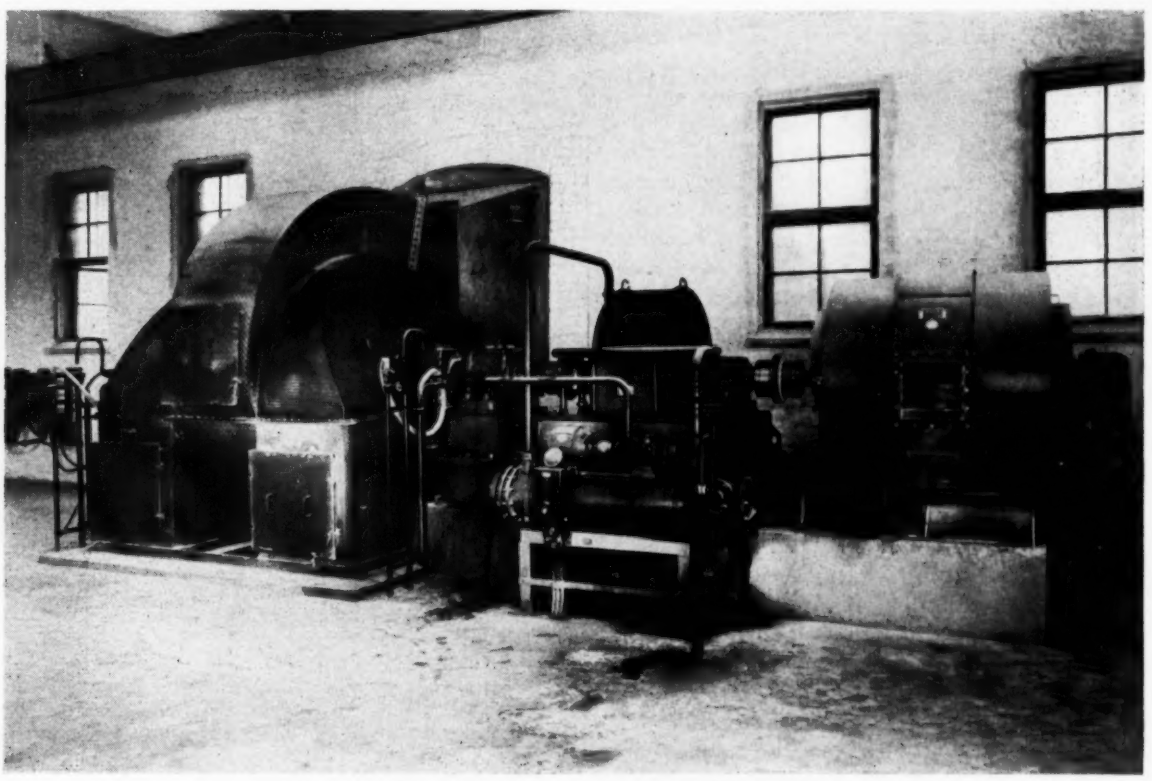


Fig. 5—Induced-draft fan driven through hydraulic coupling

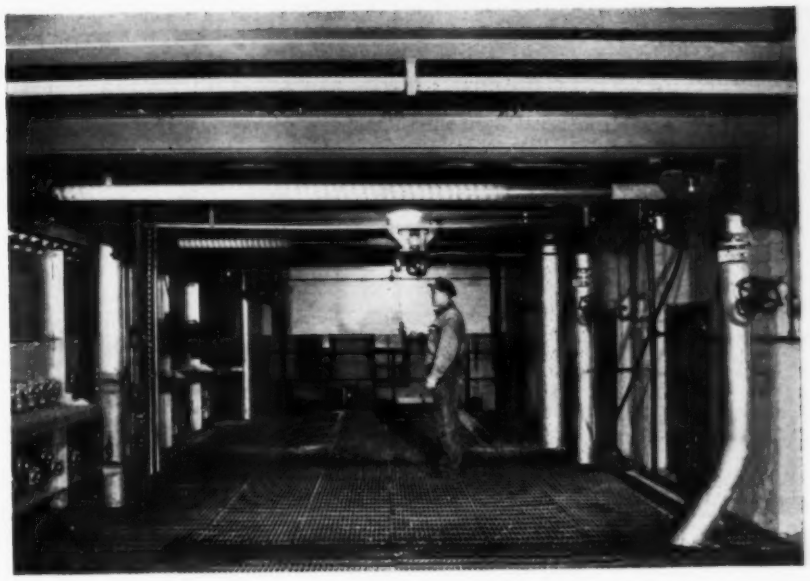


Fig. 6—Manually operated retractable-type blower

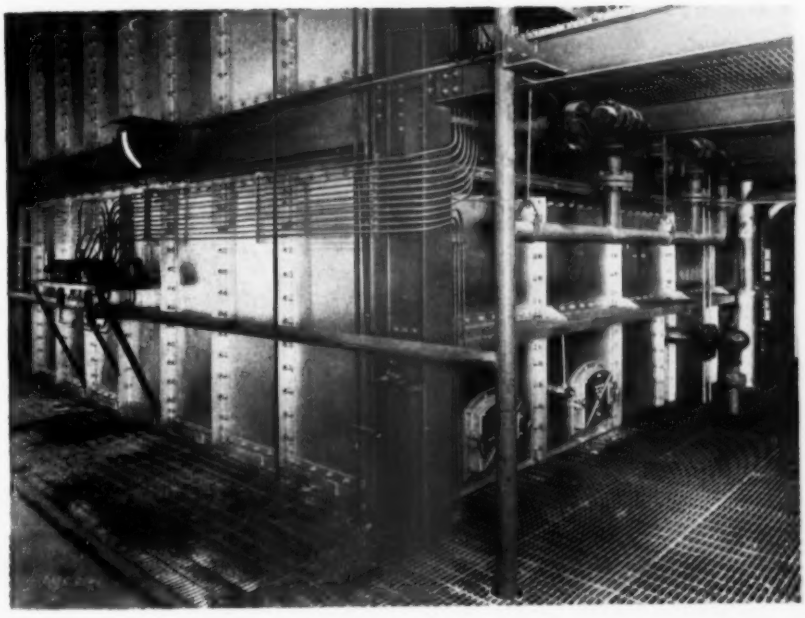


Fig. 7—Controllers for air-puff soot blowers

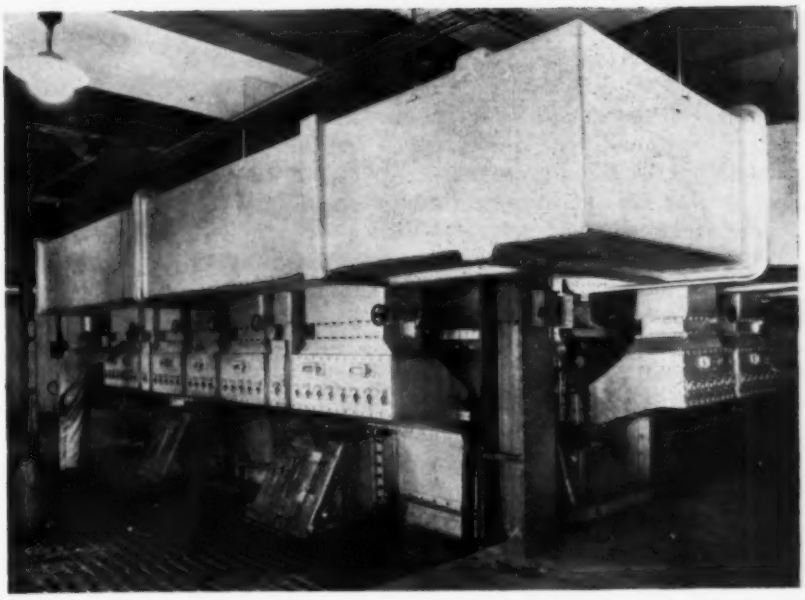


Fig. 8—Primary air ports and slag spout housings

burns out and the necessary chemical reduction of the sodium sulfate to sodium sulfide takes place.

During the hearth burning process the ash that is contained in the black liquor is melted and is drained from the furnace bottom through water-cooled troughs called smelt spouts. The ash consists entirely of sodium salts, excepting a very small percentage of impurities, and in its molten state is usually spoken of as smelt. The sodium salts are all water soluble, so the molten smelt is quenched and dissolved in a tank equipped with some means of agitation. The resulting solution is called green liquor.

Furnace

The gases from combustion pass up through the vertical furnace into the boiler screen and superheater pass located directly over the hearth. The boiler is of three-drum design, and the two upper drums are arranged as shown in Fig. 1. As indicated by the line diagram, Fig. 2, the boiler proper consists of two vertical banks, and all boiler surfaces are arranged for maximum parallel flow. The gases flow through the integral vertical-tube economizer before passing into the cascade evaporator.

The upper and lower furnace walls are constructed of 3-in. fin tubes. This makes a complete metal wall which provides maximum heat absorption from the gases of combustion and protects all refractory behind the water walls. In this manner all refractory maintenance is eliminated except for the furnace hearth. The smooth-faced surface minimizes slag accumulation on the walls and eliminates cleaning of furnace walls during operation.

The furnace hearth is constructed of chrome brick covering cinder concrete shaped to form a sloping contour for the bottom. The hearth is sloped so that the molten ash drains toward either of the two smelt spouts.

Boiler Cleaning

The black liquor solids consist of 44 per cent ash which has a fusion temperature as low as 1350 F. Since the boiler is designed for maximum parallel flow, as was mentioned previously, there is minimum impingement of entrained chemical ash on boiler tubes. Because of the wide spacing of the tubes and their arrangement, slagging conditions are minimized.

The soot blower system consists of retractable air-operated steam blowing heads for the screen tubes and superheater elements. Fig. 6 shows a manually operated retractable-type blower. The soot blowers are located overhead and are suspended from the upper floor steel. This permits maximum accessibility to the boiler on all operating levels.

The boiler and economizer passes are cleaned by automatic air-puff soot blowers. Fig. 7 shows the arrangement of the soot blowers, the air-puff heads, and the interconnecting air tubing.

Ash cleaned from the screen tubes and superheater elements falls directly to the hearth. That removed from the two boiler passes is deposited in the boiler hoppers. A portion of the black liquor fed to the cascade evaporator circulates through the bottom of the hopper and carries out the ash. The latter is dissolved in the liquor and carried back into the cascade evaporator. The ash from the economizer pass falls directly into the cascade evaporator, where it is similarly dissolved in the black liquor. This arrangement provides an automatic ash-handling system which does away with the need for any manual handling and recovers all of the chemical ash cleaned from the boiler surfaces. The wet system of ash handling affords a dust-free method which makes possible the maintenance of a clean recovery room and avoids chemical losses.

Steam Air Heater

Air for combustion is supplied by the forced-draft fan through the steam air heater, ducts and wind boxes. The arrangement of primary ports at the Kotka mill is shown in Fig. 8. Secondary air ports are located at the level of the liquor sprays.

The steam air heater gives maximum air temperature when starting up the recovery unit and also at times when the black liquor flow is momentarily interrupted and furnace temperatures are lowered. Maximum air temperature is of great advantage under both these conditions.

Steam at 125 psig is used for the steam air heater. Heat from the steam used to preheat the air is returned from the recovery unit in the high-pressure steam produced. Condensate from the steam air heater is returned to the feedwater system. With the exception of the small radiation loss there is no heat lost from that in the steam supplied to the air heater.

Instruments and Controls

Since the chemical recovery unit operates at constant ratings, an elaborate combustion control system is not necessary. As was mentioned previously, the liquor fed to the cascade evaporator is controlled to maintain a constant level. At the Kotka mill steam flow is regulated to maintain a black liquor temperature of 194 F in the primary black liquor heater. The flow of steam to the secondary black liquor heater, located between the pumps and black liquor spray, is controlled to maintain a temperature of 235 F.

A furnace-pressure regulator controls the speed of the induced-draft fan and maintains a constant furnace draft. The speed of the induced-draft fan, which is driven through a hydraulic coupling, depends upon the quantity of oil circulated within the coupling housing. The furnace-pressure regulator operates the oil pump which controls the fan speed by pumping oil into or out from the hydraulic coupling housing.

The black liquor pump is driven by a variable speed motor. The flow of black liquor is governed by the pump speed. It can also be regulated by the valve at each spray or by a valve in the black liquor circular header which controls the amount of black liquor circulated and returned to the mixing tank.

Air for combustion is controlled by the forced-draft-fan outlet damper which is moved by a gear-head motor. The motor is remotely operated by a push button on the panel board. Distribution of air to the hearth is obtained by hand-operated dampers in the wind boxes.

The remainder of the instruments at the Kotka mill are conventional types including a steam pressure gage, feedwater pressure gage, draft gages, recording steam-flow and air-flow meters and black liquor temperature recorders.

Automatic Sequential Soot Blowers—Steam Vs. Air Blowing

By Robert L. Townsend
The Kissick Company, New York

Typical sequential blower panel

AUTOMATIC sequential soot blower systems are now in successful operation on all types and sizes of boilers, using steam or compressed air, or a combination of both, as the cleaning media. There is no proof that one is better than the other in removing slag, soot and ash deposits from boilers fired with pulverized coal or oil. Therefore, other factors must be considered before selecting the blowing medium for each boiler installation, and the following information should be helpful in this respect.

Compressed air is certainly the better medium with which to work, since there are fewer mechanical problems for the soot blower manufacturer and considerably less maintenance required by the operators.

Several boilers are now being installed in various plants with automatic sequential soot blower systems designed to use steam initially as the blowing medium, and later to change over to the air blowing by simply disconnecting the steam supply and connecting the air supply to the system. Such systems require larger piping than normally used for the steam system on high-pressure boilers. One central station boiler plant now in operation uses 400 psig compressed air from only one air compressor and steam standby for soot blowing in case of compressor outage.

Air blowing will not eliminate tube cutting; in fact, there are several plants that have experienced tube erosion while using air. Where an abrasive ash is present on the tube surface, the high velocity blowing medium—either air, superheated steam or saturated steam—will pick up the ash particles and start a scouring process on the metal tube surface. Tube erosion has never been a serious problem on oil-fired boilers with any type of soot blower unit using either steam or air.

Where the fixed-position, multi-jet rotary-type soot blower unit is used for cleaning boilers fired with pulverized coal, it has been necessary to reduce the blowing nozzle pressure in some cases to as low as 80 psig to prevent tube cutting. However, large mass-type, low-velocity nozzles in the multi-jetel ement are now being used successfully in many boilers with nozzle pressures as high as 200 psig to obtain better cleaning and to alleviate tube cutting. Where this type of soot blower is located in close proximity to the boiler or superheater tubes, large straight-bore, low-velocity nozzles should always be used instead of the more efficient venturi-shape nozzles.

The use of long and short travel retractable soot blower units having two large mass-type blowing nozzles (either venturi or straight bore) in the lance has practically eliminated the danger of tube cutting, even when using nozzle pressures up to 400 psig. Retractable units can be located in any gas temperature zone, and since the energy is confined to only two large mass-type nozzles, the effective cleaning range is double (from 6 ft to 8 ft) that obtained with the fixed-position, multi-jet rotary element having many smaller nozzles.

The trend in the central station boiler installation is toward the use of the more efficient retractable unit, even in the economizer. Fewer units are required and they are less costly to maintain than the multi-jet rotary units, since they are withdrawn from the boiler when not in service.

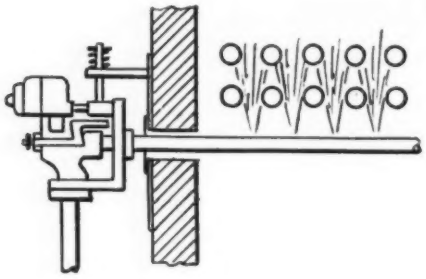
Air blowing has not been too effective in cleaning boilers fired with fuel oil containing vanadium salts, sulfur and other minerals. This may be due to the following three causes:

1. Insufficient air pressure.
2. Insufficient volume.
3. Soot blowers not operated often enough.

Where the deposit on the tubes is difficult to remove, it requires a large mass of air or steam at high velocity for adequate cleaning. Moreover, the soot blowers must be operated often enough to keep the deposit from building up.

Boilers operated at high continuous rating twenty-four hours per day will require more soot blower units in the slagging zones, and require more frequent operation than boilers operated at intermittent loads. This is a point that must be given consideration when air is selected, since it will be a factor in deciding the compressor capacity.

In the design stage, where in many cases the future load conditions are unknown, it is the general practice to



Multi-jet rotary type

install wall boxes and sealing plates for possible future soot blower units.

The advantages and disadvantages of steam and compressed air as cleaning media are as follows:

Steam

ADVANTAGES

1. Lower cost of steam over compressed air.
2. Ample volume of steam available at any required pressure on high-pressure boilers.
3. Blowing cycle completed in less time than with compressed air at limited volume. (Limited because of cost.)
4. Lower initial cost of the steam system installed.

DISADVANTAGES

1. More frequent packing replacement.
2. Higher maintenance on blower elements, steam control valves, reducing valves and piping.
3. Covering required for the steam piping.
4. Increases boiler makeup by 0.25 to 0.7 per cent.

Compressed Air

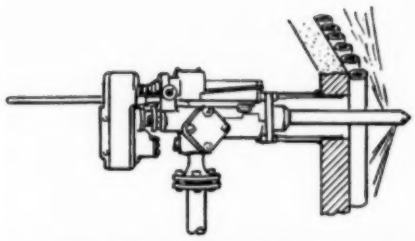
ADVANTAGES

1. Decreases makeup water by 0.25 to 0.7 per cent. Air blowing, naturally, conserves water which has two important bearings:

   (*a*) In areas where water is at a premium, anything that can be done to conserve it is an advantage.

   (*b*) If, because of impurities in makeup, there is carryover of solids such as silica into the turbine, then air blowing is clearly justified. However, this condition is perhaps one of relativity in that we should avoid carryover.

2. Elimination of pipe covering.
3. Elimination of frequent packing replacement.



Gun type blower for automatic push-button operation

4. Elimination of expansion and contraction in the entire soot blower system.
5. Lower maintenance cost for the entire soot blower system.

DISADVANTAGES

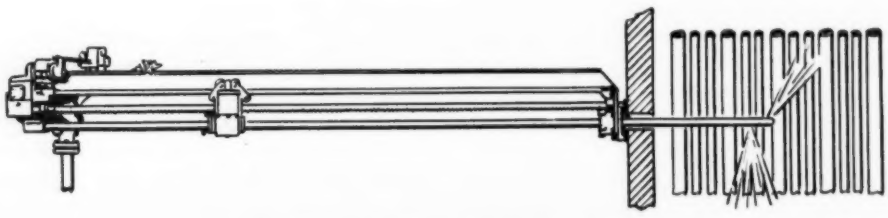
1. High cost of compressors, receivers, piping and reducing valves.
2. Longer time required to complete the blowing cycle unless ample compressor and receiver capacity is provided.
3. Frequency of soot blower operation is limited to the capacity of the air compressors and receivers installed.
4. Cost of electric power for compressing air.
5. Pressure required for adequate cleaning is limited to the air compressor pressure.

When it is necessary to estimate the comparative costs of the steam and air blowing systems, it can be assumed that the cost for the soot blower units, piping, valves and controls will be the same for either medium. Therefore, for the air blowing system, the cost of air compressors, air receivers, pressure reducing valves and connecting piping should be added to the soot blower material price.

The following steam and air consumption figures were estimated for cleaning one 800,000 lb per hr boiler in a central station:

Boiler	800,000 lb per hr
Steam for soot blowers	450 psig, 700 F
Air for soot blowers	500 psig, reduced to 300 psig
Fuel	Pulverized coal and oil
Number of soot blower units	22
Type of soot blowers	10 Short retractable deslaggers 10 Long retractable 2 Air-heater cleaners
Type of soot blower operation	Automatic sequential Air-actuated
Soot blower operation per day	3 times
Blowing time for 3 cycles per day	6 hr

Steam Blowing per Day		*Air Blowing per Day*	
Blowing steam	62,100 lb	Blowing air	818,000 cu ft
Warming up and drains	6,900 lb	Power and control	22,000 cu ft
Power and control air	22,000 cu ft		



Long retractable unit, partially extended

For air blowing, this system would require two 550-cfm air compressors at 500 psig and one 800 cu ft air receiver at 500 psig.

When air is selected as the blowing medium, the size and number of air compressors, size and number of air receivers, and the blowing pressure depend on the following:

1. Size and capacity of boiler.
2. Number of boilers.
3. Kind of fuel burned.
4. Method of firing.
5. Fusion temperature of ash in fuel.
6. Continuous or intermittent load.
7. Number of soot blower units.
8. Types of soot blower units, i.e., short retractable, long retractable, rotary and stationary.
9. Frequency of soot blower operation.

There are two types of automatic sequential air blowing systems, the intermittent blast or puff system and the continuous blowing system.

The intermittent blast or puff system is designed for use on boilers where the air compressor and receiver capacity is limited to the maximum time allowable to clean the boiler. For cleaning fire-tube and small water-tube boilers, this system generally operates at 100 psig to 150 psig air pressure. Multi-jet rotary-type soot blowers are used for this system and they operate in short intermittent blasts or puffs of from one to three seconds. A time-lag between blasts allows the compressor to build up again sufficient pressure and volume in the receiver for the next blast.

The total elapsed time for cleaning the boiler with the intermittent system depends on the total amount of free air required for the entire blowing cycle and the capacity of the air compressor. The intermittent blast or puff system is never used for retractable soot blower units unless they are located in the low gas temperature zones.

The continuous blowing system is used on large boilers which are equipped with long and/or short retractable soot blower units. This system requires sufficient air compressor and receiver capacity to operate each retractable blower through its entire blowing cycle while maintaining a constant nozzle pressure. Air pressures for the continuous automatic sequential system vary from 350 psig to 500 psig, while the soot blower nozzle pressure will vary from 100 psig for moving dry ash and soot to 300 psig for slag and heavy deposits.

Boilers operating at high continuous rating may require the soot blowers to operate every two or four hours in the slagging zones, while the blowers in the cooler passes may require only one operation in twenty-four hours.

An automatic sequential soot blower system for large boilers should have complete flexibility in controlling the operation and should be designed with the following features:

1. Operation of units individually at the panel or at the unit.
2. Operation of any number of pre-selected units in automatic sequence.
3. Operation of all units in proper sequence.

Soot blowers should only be operated often enough in the various zones to keep the surface clean and to maintain normal gas temperatures throughout the entire steam generating unit.

Facts and Figures

We now have some 300,000 miles of pipe lines carrying oil and natural gas.

•

More than 90 per cent of bituminous coal produced in the United States comes from eight states.

•

The average industrial worker in the United States uses approximately three times as much electricity as does the British worker.

•

The installed capacity of electric generating plants in India is expected to increase 72 per cent within the next three years.

•

A British patent on underground gasification of coal was taken out as early as 1909, although the idea was proposed many years before that.

•

One out of every three freight cars on American railroads transports coal, and the freight income from this source amounts to over a billion dollars annually.

•

The total power requirements of the Missouri River Basin are estimated by the Federal Power Commission to reach between 44 and 45 billion kilowatts by the year 1970.

•

The most powerful jet engine reported to date develops the equivalent of 14,000 hp.

•

The amount of coal burned by the central power stations in New York City in a single day is estimated by the Bituminous Coal Institute to be equivalent to a coal train four miles long.

•

A new record for world production of crude oil was reached for the year 1950 with an estimated total output of slightly over $3^3/_4$ billion barrels. Of this, our domestic production accounted for over one-half.

•

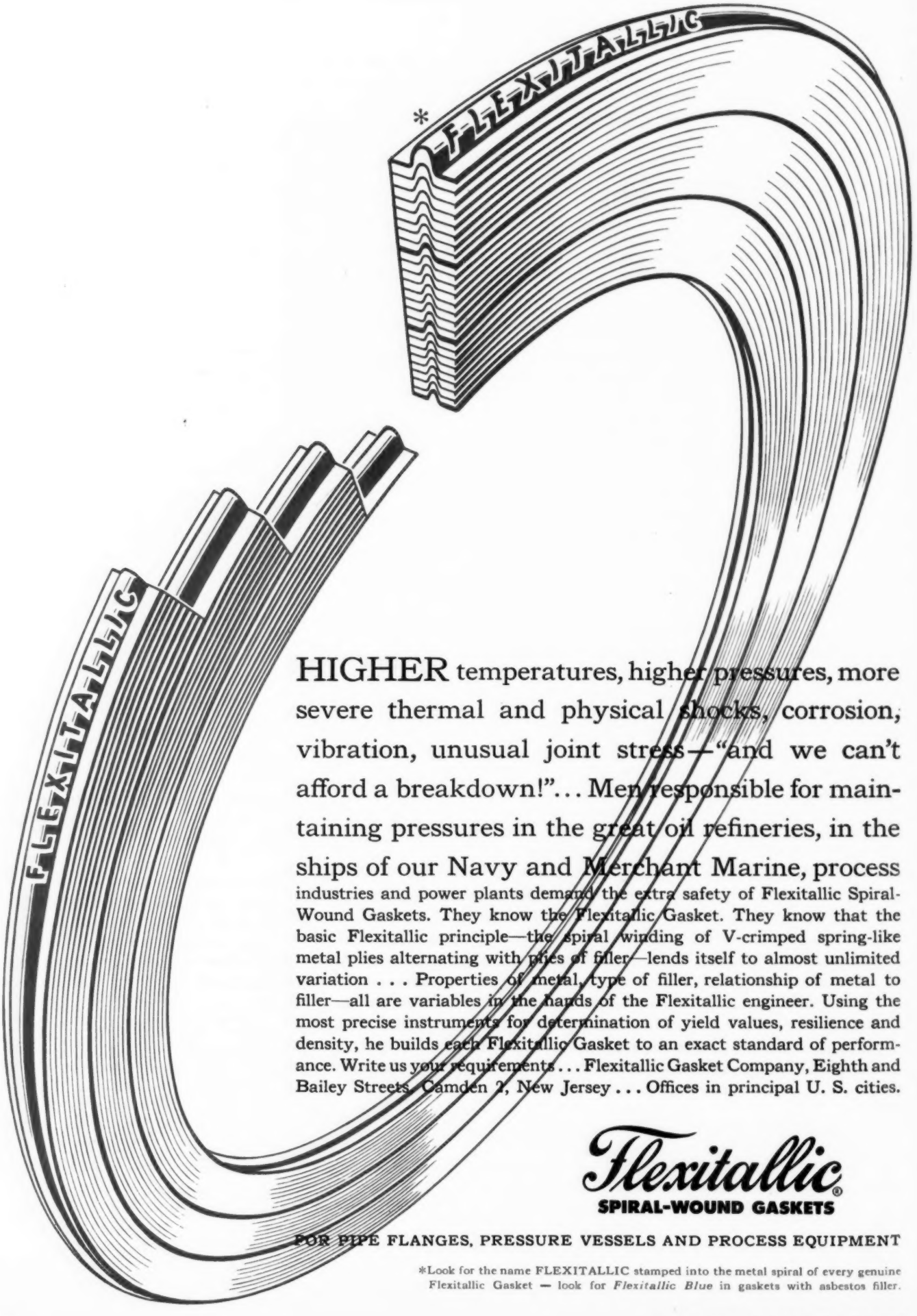
Thermocouples operate on the principle of the "Seebeck Effect," discovered in 1821, when it was observed that an electromotive force is set up in a circuit of two dissimilar metals when either of the junctions is warmer than the other. A single thermocouple may have but a few microvolts potential difference per degree difference in junction temperatures.

•

One large turbine builder, responsible for turning out 2,866,000 kw capacity in 1950, reports that more than half the units were for pressures in excess of 1251 psi: 27 per cent ranged from 1450 to 2000 psi; 26 per cent were in the 951 to 1050 F temperature range; and reheat machines accounted for a quarter of the total.

•

Complete figures on bituminous coal distribution show that the electric power utilities purchased 88,261,000 tons in 1950 as compared with 80,717,000 tons in 1949. This represents an increase of over nine per cent. As an industry they were exceeded only by-product coke ovens.



HIGHER temperatures, higher pressures, more severe thermal and physical shocks, corrosion, vibration, unusual joint stress—"and we can't afford a breakdown!"... Men responsible for maintaining pressures in the great oil refineries, in the ships of our Navy and Merchant Marine, process industries and power plants demand the extra safety of Flexitallic Spiral-Wound Gaskets. They know the Flexitallic Gasket. They know that the basic Flexitallic principle—the spiral winding of V-crimped spring-like metal plies alternating with plies of filler—lends itself to almost unlimited variation . . . Properties of metal, type of filler, relationship of metal to filler—all are variables in the hands of the Flexitallic engineer. Using the most precise instruments for determination of yield values, resilience and density, he builds each Flexitallic Gasket to an exact standard of performance. Write us your requirements . . . Flexitallic Gasket Company, Eighth and Bailey Streets, Camden 7, New Jersey . . . Offices in principal U. S. cities.

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Reducing the Cost of Steam in Coal-Fired Boiler Plants

By CARL E. MILLER

Combustion Engineering-Superheater, Inc.

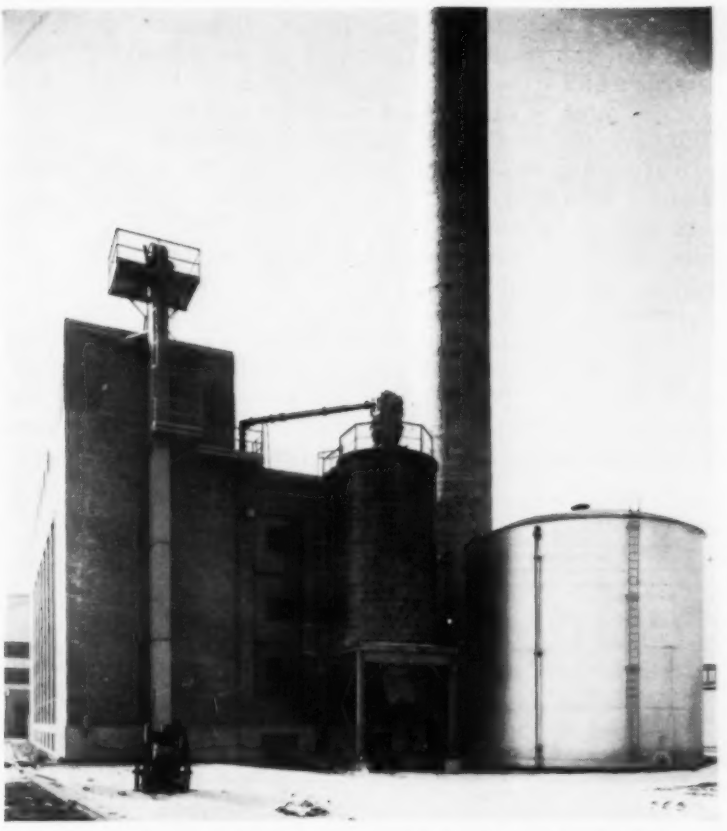

Fig. 1—Rear of plant showing coal elevator and ash silo

In this paper presented at the Fairmont Coal Conference in Philadelphia on January 24, 1951, the author discusses the prerequisites of small plant design for economy and ease of operation with particular reference to standardized boilers and single-retort underfeed stokers for steam outputs up to 35,000 lb per hr. A typical plant is described.

IN recent months, the unsettled foreign situation has re-emphasized the necessity for considering coal as the prime source of energy for the generation of steam in industrial plants. Its relative price stability, the ease with which it may be stored, and its assured supply have definite appeal.

Admittedly, in recent years the use of oil and gaseous fuels has increased substantially in the industrial field, particularly along the Eastern Seaboard. Generally, the reason for this has been attributed to reduced labor requirements and greater convenience. In many cases, the use of liquid and gaseous fuels is definitely justified. On the other hand, many economic studies have shown oil and gaseous fuels more advantageous only because obsolete designs of coal-fired installations were used for purposes of comparison.

It is the object of this discussion to illustrate typical features of modern coal-fired plants. Such features, properly applied, will result in an installation which will have all the advantages of convenience, cleanliness, and reduced labor requirements. In such plants, the cost of conservatively designed boilers and stokers, and adequate coal- and ash-handling equipment will generally increase the initial investment required over that of liquid and gaseous fuels. In many cases, however, if fuel costs as well as the improved operation and reduced cost of labor of an automatic coal plant are evaluated, the investment is more than justified.

In a broad sense, a discussion of the subject of reducing steam costs falls into three categories, each important and all interrelated. They are:

1. Plant layout and selection of equipment.
2. Selection of proper fuel.
3. Establishment of sound operating principles.

However this discussion will be confined to plant layout and selection of equipment. To limit the scope further only stoker-fired boiler plants of the industrial classification will be considered. As plant layout and equipment are basic in any plan of reducing steam costs and a prerequisite for obtaining results from improved fuel selection and operation, this procedure seems most appropriate. To illustrate the application of some of the factors involved, an actual plant has been selected and will be described in some detail.

Plant Layout and Selection of Equipment

Many things must be considered in choosing a suitable arrangement in the selection of equipment for a modern coal-fired plant but there is probably none as important

as the boiler and its firing equipment. Engineers are aware that the steam generator and its accompanying stoker must have the correct characteristics for the plant load, and must be designed for maximum fuel flexibility if full benefit of economy in operation is to be had.

To attain this objective at minimum cost, the modern trend has been toward the increased use of standardized steam generating units. These have integrated components—that is, the boiler, furnace, and fuel-burning equipment are so correlated that the best overall proportions are provided. Fans, cinder collectors, and controls for combustion and water level are furnished as part of the standard unit so that each part is suitable for its particular function. Through this correlation not only is operation more efficient, but of equal interest to the industrial plant is the fact that the highly developed engineering entering into the original design of these standard units results in reduced maintenance and minimum outage. Even more important, through reduced engineering and shop costs, more steam capacity can be furnished to the user for each dollar invested.

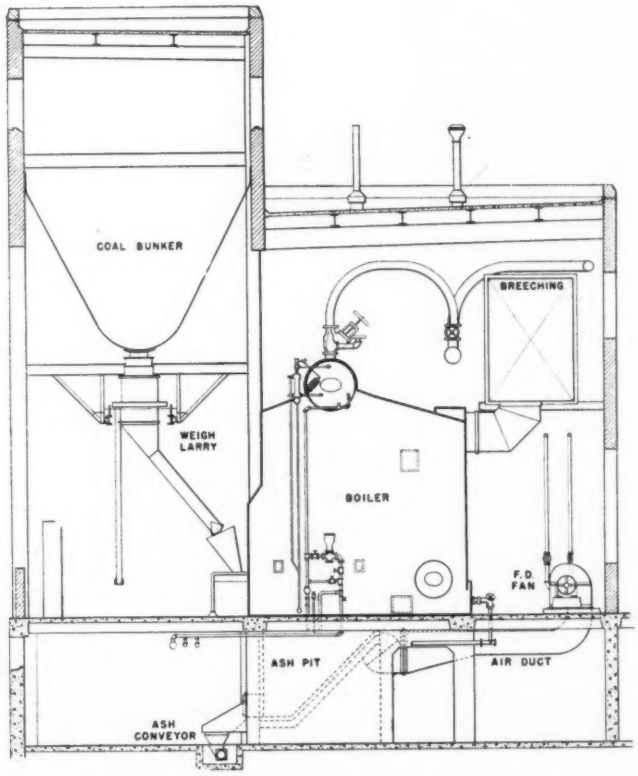

Fig. 2—Section showing general arrangement of model boiler plant

Selection of the proper type of stoker can hardly be over-emphasized. In the East, most of the bituminous coals available are of the caking type and underfeed stokers, designed to handle this type of coal, have been proved in service for many years. Present practice favors the single-retort stoker within its capacity range which is from about 1000 to 35,000 lb of steam per hour. Beyond that capacity the spreader stoker is generally used, although the chain or traveling grates are showing increasing popularity in the Midwest and western areas.

The underfeed stoker is particularly well adapted to banking or carrying light loads and can be used for readily picking up sudden emergency loads of considerable magnitude. Another advantage is that a properly sized underfeed stoker is less likely to cause fly ash nuisance, so that the installation of a cinder collector is necessary only in exceptional cases.

Choosing the proper size of single-retort stoker for a given boiler requires careful analysis. Although the usual criteria is to base the stoker size on total grate area, a much more accurate procedure is to use active grate area, or some modification that takes this into consideration.

If an analysis is made of single-retort underfeed stoker construction, the reason for basing the selection on active grate area is obvious. Some air is admitted to the retort and dump-grate sections in this type of stoker, but it is generally conceded that these sections are relatively ineffective compared to the active grate bar area. The width of the retort and the dump-grate sections are a relatively constant value for any width stoker. Thus, the important variable—the length of grate bar—varies almost directly with the total width of the stoker after a fixed allowance has been made for the retort and dump grates.

This can best be illustrated by a specific example. Consider a stoker 6 ft wide and 9 ft long, having a total grate area of 54 sq ft. After allowing for a width of 2 ft 10 in. for retort and dump grates, this stoker will have a *total active grate area* of about 28.5 sq ft. On the other hand, a stoker 9 ft wide and 6 ft long (having the same total grate area of 54 sq ft) after allowing for the same width for retort and dump grates, will have an *active grate area* of about 37 sq ft. In other words, the second stoker will have a 30 per cent greater active grate area even though the total area of the two stokers is the same. A typical way of allowing for this width factor is by varying the allowable burning rates for the entire stoker as illustrated in the following table:

TYPICAL RELATION BETWEEN STOKER WIDTH AND ALLOWABLE BURNING RATES

Total Width of Stoker	Pounds of Coal Burned per Square foot of Nominal Grate per Hour
6	24
7	27
8	30
9	31
10	33
11	34
12	36

Above the capacity range of the single-retort underfeed, the spreader stoker is the usual choice. This type has in recent years generally replaced the multiple-retort stoker, because of its lower first cost, lower maintenance, and greater fuel flexibility. Spreader stokers have the advantage of greater overload capacity and ability to utilize coal having an ash with low softening temperature. However, to avoid a fly-ash nuisance, the installation of a cinder collector is recommended.

Coal and Ash Handling

Another major factor often overlooked in the design of many coal-fired plants is provision of adequate facilities for mechanically handling the fuel and ash. It seems odd that many industries go to great lengths to mechanize

every part of their production plant, then leave out the very simplest of labor saving devices in the boiler room. A description of even a few of the systems available is too lengthy to be included here. However, the important thing to recognize is that suitable equipment is available for all sizes of plants. For very small capacities, a simple motor-driven larry and hoist costing but a few hundred dollars is available. In the larger capacity plants more elaborate equipment can be chosen such as railroad car unloaders, coal elevators and conveyors, overhead bunkers and vacuum ash-handling systems. The type to be selected will depend on the quantities of coal and ash to be handled and will be justified on the basis of improved operation and reduced labor requirements.

Model Plant

An example of a modern well-designed coal-fired plant is that of the Perfection Stove Company, Cleveland, Ohio. This plant has three 30,000-lb per hr boilers fired with single-retort underfeed stokers and operates twenty-four hours a day, seven days a week. Reliability and economy of operation were basic considerations in the design. The selection of equipment and plant arrangement are such as to provide lowest fuel costs and minimum labor requirements. Conservatively designed firing equipment was chosen to allow the use of whatever coal might be available at minimum cost. Operating personnel were provided with proper tools such as automatic combustion control, adequate instrumentation, and complete coal- and ash-handling equipment, so that their time could be used effectively in maintaining the plant at its highest operating efficiency.

Fig. 2 shows the sectional arrangement of major equipment. This is typical in many ways of intermediate and larger sizes of plants and has been proved of sound design from both an operating and economic standpoint. A large overhead bunker provides adequate coal storage and a weigh larry is used to distribute the coal from any part of the bunker to any boiler. This system gives maximum flexibility and at the same time insures a substantial quantity of coal stored under cover, available for any emergency such as sustained cold weather or severe snow. A wide, well-lighted boiler firing aisle contributes to pleasant working conditions. Sloping ash hoppers are provided under the stoker and the entire ash-removal system is concentrated in the basement. The combination of sloping hoppers and vacuum ash-conveying system practically eliminates all hand labor in the ash-removal process. Also, by placing the ash-removal system in the basement, even the small amount of dust resulting from the removal operation is eliminated from the boiler room so that the plant is kept clean with a minimum of labor. The forced-draft fan is located at the rear of the boiler where it is accessible but where it does not interfere with any of the working space in the front or at the sides of the boiler.

The photograph on the cover of this issue shows particularly the cleanliness, excellent light, and the unusually fine working conditions typical of the entire plant. The clear working space in front of the boilers provides easy accessibility to the stoker, its controls and all of the boiler auxiliaries. The central location of the motor-driven weigh larry and the boiler gage board simplify the operator's duties. The unusual lighting is the result of the generous use of glass block in three of the four boiler room walls. These walls are almost entirely glass block with a few standard window inserts provided for ventilation. For additional ease in cleaning the plant and improving its appearance, the remainder of the interior wall is glazed tile and the floor red tile.

Fig. 3 shows a unique method of keeping coal dust out of the boiler room when the weigh larry is being filled from the bunker. A sliding cover is provided for sealing the joint between the bottom of the bunker and the

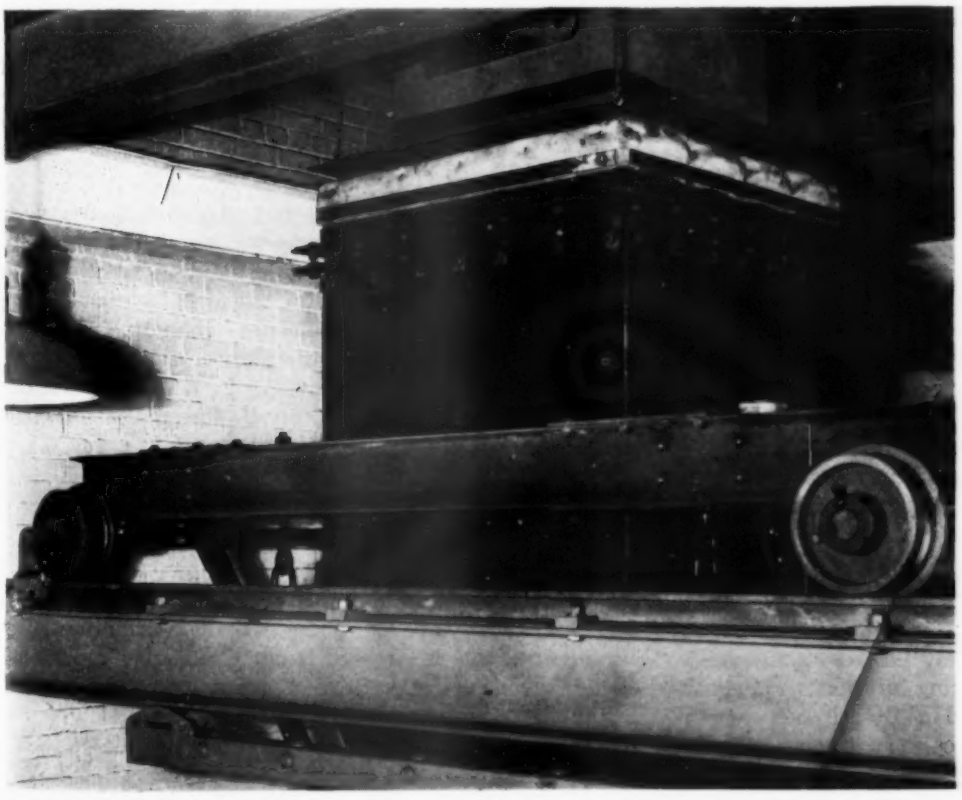

Fig. 3—Weigh larry showing dust hood connection

larry. This sliding cover is lowered automatically when the clam shell in the bottom of the bunker is opened, and seals against the flexible canvass on the top of the weigh larry.

The access door to the ash pit for removing ash is located at a good working height so that pulling ashes from the front of the sloping ashpit into the opening of the pneumatic system is an easy operation. Here, too, the use of adequate hoppers over the conveyor openings helps to maintain clean working conditions even in the basement area.

Fig. 1 shows the coal elevator and ash silo. Coal is delivered by railroad car and dumped into an under-track hopper. An elevator lifts it up to the top of the plant where it is distributed across the bunker by a belt conveyor. The tile ash silo is located sufficiently high so that trucks can be loaded directly. A brick chimney provides the necessary draft. Use of underfeed stokers operated at conservative burning rates precludes the necessity of installing induced-draft fans and cinder collectors such as are required for some types of firing.

Fig. 4 is a cross-sectional view of the boiler and stoker showing details of construction. This design is a standard for firing with underfeed stokers as well as other types of firing. The underfeed stoker has been proved through the years to be a reliable, and efficient machine for burning most coals—both caking and noncaking types. Its operating flexibility is particularly well adapted to heating loads or general industrial plants where long periods of light load are experienced. Bituminous coals with low ash-softening temperature can be effectively utilized if the stoker is conservatively rated for the load conditions to be encountered so that clinker formation is avoided. This also results in minimum fly ash emission.

In this unit, as in any well-designed, standardized unit the principal feature is the relationship of the major components—boiler, water-cooled furnace and fuel-burning equipment. For proper operation this relation must be correct both between the individual components, and to the unit as a whole. Where required because of load conditions or type of fuel supply, this same standard boiler can be adapted to other methods of firing.

Spreader Stokers

Spreader stokers are highly adaptable to burning the lower grades of coal particularly the smaller sizes and those having a low ash-softening temperature. Their operating characteristics are such that they are not ideally adapted to carrying very light load or banking, but they are well adapted to carrying continuous, heavy and fluctuating loads so common in many industrial plants. Due to the suspension burning, fly ash emission is an inherent characteristic of spreader stoker firing. A part of this carryover is caught in the rear passes of the boiler, and the remainder is discharged. Most plants require the installation of an efficient dust collector if a fly ash nuisance is to be avoided.

In some areas, the traveling- or chain-grate stoker is often the best overall choice. The traveling grate has excellent flexibility and effectively utilizes anthracite as well as many kinds of free-burning bituminous and subbituminous coal and lignite. The fly-ash carryover is relatively low, if the unit is conservatively designed. Another advantage of this type of stoker is that ash is discharged from the stoker to a single pit at the rear, where a simple inexpensive mechanical conveyor is usually adequate for its automatic handling.

Conclusions

Careful design and selection of equipment for coal-fired boiler plants can result in high efficiency, simplified operation, and low operating costs. Regardless of the type of load or the coal available, suitable stoker equipment to meet the requirements is available, as part of a standardized design. It is regretted that there are not more plants as carefully designed and planned as the one illustrated. Part of this is probably due to the fact that there are such a large number of obsolete coal-fired plants still

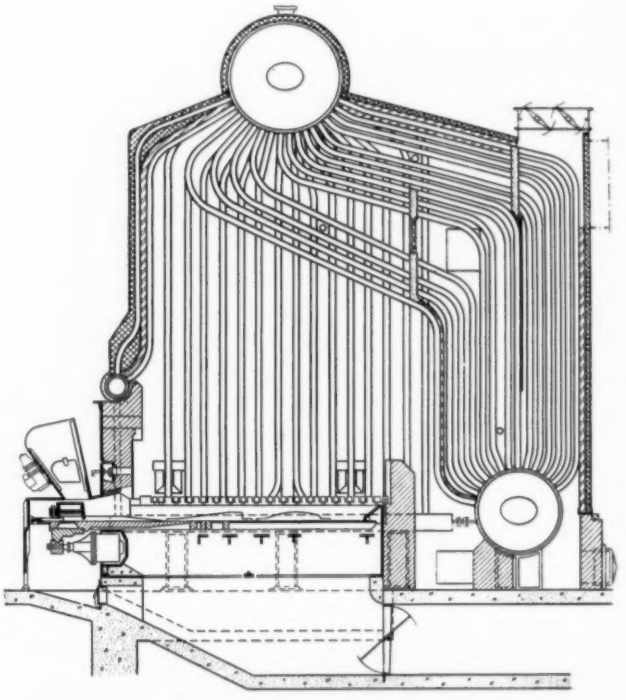

Fig. 4—Cross-section of boiler and stoker

in operation. Undoubtedly, as replacements are made within the next few years, there will be a substantial increase in the number of improved plants. To effect this improvement, greater cooperation must be effected between the major interested parties—namely, the industrial user, the equipment manufacturer and the consulting engineer. This approach offers the surest possibilities in attaining the ultimate objective—lowered steam costs to industry.

Acknowledgment

Much of the illustrative material used in describing this plant of the Perfection Stove Company was received through the courtesy of Alice Holten, Publicity Director for Perfection Stove Company. G. I. Chittenden, Vice President of the George S. Rider Company, consulting engineers for Perfection Stove Company, was particularly helpful in providing design information and drawings of the plant. Their cooperation in making this material available is greatly appreciated.

Determination of Alkalinity Relationships*

By W. J. JOHNSON† and N. T. ROSSITER‡

In boiler waters the determination of hydroxide alkalinity has hitherto been subject to errors brought about by the presence of dissolved silica. A procedure for overcoming this difficulty is described. For this purpose the dissolved silica must be ascertained quantitatively. The method involves the separate determination of phosphate and silicate and a titration of the boiler water, covering these salts. From these data, free hydroxide can be found with fair accuracy.

IN the control of internal boiler-water conditioning for medium- and high-pressure boilers there is need for a procedure capable of determining the concentrations of all the sodium salts which take part, by hydrolysis, in the production of effective alkalinity.

This alkalinity is produced either by accumulation of alkali from the feedwater or by deliberate addition of alkaline salts, the modern trend with deaerated feedwater being to keep the boiler-water pH value between 10.5 and 11. At the temperatures corresponding to boiler pressures of 250 lb per sq in. or more, alkali carbonates in solution become almost completely dissociated, so that, unless fed continuously to the boiler, very little carbonate is found in the boiler water. In modern practice the internal treatment of such boiler waters is based on the use of stable alkaline salts of weak acids, particularly trisodium phosphate, added in controlled amounts either continuously or intermittently.

In addition, silica is usually present in boilers, being derived either from the feedwater or sources of leakage, such as condensers or carryover from evaporators. Organic matter can also occur from the same sources.

The present paper is an account of the evolution of a procedure designed specifically for the control testing of boiler waters having the following characteristics:

pH value	10.7 to 11
Caustic alkalinity	Absent
Phosphate (as PO_4)	50 to 100 ppm
Carbonate (as CO_3)	Less than 2 ppm
Silicate (as SiO_3)	Up to 50 ppm
Organic matter	Present

Neutral sodium salts, such as chloride and sulfate, are not significant in this discussion, as they take no part in the alkalinity relationships. They are therefore excluded from consideration. Although suspended matter is present in many boilers it is to be understood that throughout the following discussion the boiler-water samples have been effectively filtered in sampling. These are boiler waters from which free caustic is deliberately excluded and the necessary alkalinity maintained by the addition of sodium phosphate, plus the adventitious sodium silicate.

The original aim of the treatment was to maintain the required pH value by means of trisodium phosphate. In order to provide a buffer against possible development of free caustic by reaction of trisodium phosphate with carbonates and bicarbonates, a reserve was to be maintained of disodium phosphate which would react immediately with caustic soda to form trisodium phosphate. This reserve could be expressed in terms of disodium phosphate, or as the amount of soda which would be required to convert the Na_2HPO_4 present to Na_3PO_4, for which the term "Soda Deficiency" was coined.

From the outset it became obvious that dissolved silica interfered with this clear-cut conception and that available methods could not give a reliable quantitative figure for the "soda deficiency" or for small amounts of free caustic soda, in the presence of silica.

Existing Methods

The existing methods which showed promise of being useful, subject to modification, were:

1. Titration of the boiler water to phenolphthalein (P) and methyl orange (M) end points, or their equivalents, along with the determination of phosphate by back titration from M to P(1).[1]

This type of method gave unreliable results because of interference from organic matter and the fact that the titratable value of the silicate present was ignored.

2. Precipitation of the phosphate radical by means of strontium chloride (or similar salt), with or without added sodium hydroxide, and titration of the resultant solution in the presence of the precipitate—Winkler method, modified (2, 3).

Practical tests with this method showed it to be subject to at least three sources of error: (*a*) Appreciable amounts of a basic strontium phosphate are precipitated, giving a negative error for hydroxide. (*b*) Resolution of the precipitated phosphate during titration, giving a positive error. Although this is a compensating error to (*a*) the balance is not achieved at the recommended end point of pH 9.3, where very little, if any, of the basic phosphate is redissolved. (*c*) Very little of the silicate is precipitated by the strontium salt and most of the remainder is titrated, giving a positive error.

3. Determination of the phosphate content and pH value of the boiler water, plotting these values against each other and relating the resultant point to a pH-Na_3PO_4 concentration curve plotted to the same scales (4). This method takes no account of alkaline salts, such as silicate, which affect the pH value.

To avoid confusion it should be emphasized that, except in so far as ionic activity determines the resultant pH value, this paper is concerned with the estimation of stoichiometric relationships of the alkaline salts, rather than with the ionic activities dealt with by McKinney (5) and used in A.S.T.M. Method D515-43 (6). Straub (1) states that "unless the pH of the solution is above 12, there is less than one-third of the phosphate titrated (at pH 8.5), since it will not be completely converted to trisodium phosphate below a pH of 12." The authors have not found this to be the case in trisodium phosphate solutions (free from contamination) at PO_4 concentrations up to 100 ppm (pH 10.93). The statement appears to result from confusion of the two aspects.

Experimental

Synthetic Solutions

Synthetic working solutions were carefully prepared from the following stock solutions, which were preserved in well-stoppered, wax-lined bottles and checked for impurities as needed. Further similar stock solutions were made up as required. The distilled water used for all these solutions had a conductivity of less than 1×10^{-6} ohm^{-1} per cm. (3).

All sodium phosphate solutions were made up from sodium dihydrogen phosphate ($NaH_2PO_4 2H_2O$) of A.R. grade, as this was found to be free from contamination. The A.R. trisodium phosphate was found to contain both carbonate

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* Excerpts from a paper before The Royal Australian Chemical Institute, reprinted in the *Proceedings* of that body.

† Chemist-in-charge and ‡ chemist of the State Electricity Commission of Victoria at Yallourn Power Station.

[1] Numbers in parentheses pertain to references at end of paper.

(1.75 per cent as Na_2CO_3) and silicate (0.75 per cent as Na_2SiO_3). Both this salt and the disodium phosphate were deficient in water of crystallization. Carbonate was determined by a modification of the wet-evolution method of F. J. Watson (7). Sulfuric acid was used in place of hydrochloric acid, as the latter gave an appreciable blank, due presumably to the vapor pressure of the HCl in the evacuated system, which is undesirable when very small quantities of CO_2 are being determined. Phenolphthalein was replaced by a screened indicator for greater precision in determining the end point. It was also found that with the very small quantities of CO_2 involved and using $N/50$ standard acid as little as 0.2 mg of CO_2 could be determined by forward titration in presence of the barium carbonate precipitate. Silica was determined gravimetrically and colorimetrically. The phosphate content was determined by precipitation as ammonium phosphomolybdate (8) and colorimetrically. In the working solutions, it was checked by titration from pH 8.6 to 5.4, boiling and back titrating to 8.6, these being the appropriate end points of Na_2HPO_4 and NaH_2PO_4 for the $M/1000$ solutions used. Trisodium and disodium phosphate solutions were made by adding the calculated amounts of the sodium hydroxide solution to the dihydrogen phosphate solution.

Sodium metasilicate was made up by first fusing pure ground quartz, acid- and water-washed, with less than its molecular equivalent of A.R. sodium hydroxide. The silica in the resulting solution was determined gravimetrically and the soda by potentiometric titration to pH 6.5. The titration curve given by Britton (9) was reproduced experimentally (Fig. 1). Using these data the required amount of the sodium hydroxide solution was added to bring the Na_2O:SiO_2 ratio to unity. The carbonate content was found to be 0.3 per cent (as CO_2) of the Na_2SiO_3 present.

Sodium hydroxide solution was prepared from a fresh bottle of A.R. grade by way of a 100 g concentrated solution of NaOH to 100 ml of water. The working solution was tested for carbonate and silicate and found to be effectively free from both.

Coordinated pH-PO_4 Method

Using pure trisodium phosphate solutions a pH-P_2O_5 concentration curve was established (Fig. 2) relating concentration of trisodium phosphate (in terms of P_2O_5) to pH value. By careful work it was found that the pH values could be reproduced to within about ± 0.03 unit using a L.&N. pH meter, and a glass electrode. To maintain this accuracy it was necessary not only to calibrate each new glass electrode but to repeat this calibration at intervals during the life of the electrode. The curve produced was found to agree with that shown by Purcell and Whirl (4). These workers used the curve to determine the presence or absence of hydroxide alkalinity in phosphate-treated boiler waters. Their procedure was to determine the phosphate content and pH value of the boiler water, plot the result-

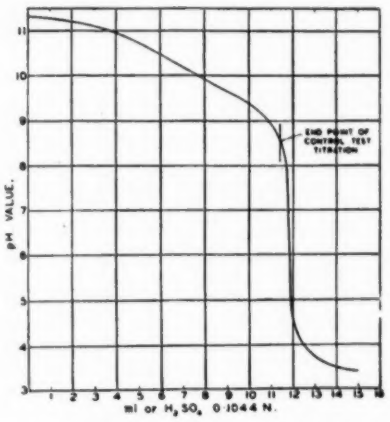

Fig. 1—Titration of sodium metasilicate

Solution: SiO_2—0.25 g/l; Na_2O—0.255 g/l and CO_2—0.0016 g/l

ant point and ascertain from its position with relation to the curve whether or not hydroxide was present. Three conditions are possible. If the point falls above the curve hydroxide is assumed to be present. If it falls on the curve all the phosphate is present as Na_3PO_4 and hydroxide is absent. If it falls below the curve some phosphate is present as Na_2HPO_4.

The second condition having been reproduced by the construction of the curve, the third condition was verified by making varying additions of Na_2HPO_4 to different strengths of Na_3PO_4 solutions having pH values above 9.7 and determining the resultant pH values.

The first condition was found to be valid where only sodium hydroxide and trisodium phosphate existed in the solution. It was soon discovered, however, that the addition of sodium metasilicate to pure trisodium phosphate solutions indicated the presence of proportionate amounts of hydroxide, though none had been added as such.

Silicate Alkalinity

The titration curve for sodium silicate (Fig. 1) shows conclusively that the silica is present in combination with the soda and is titratable, with a defined end point at pH 6.5 for the concentration used. In boiler waters, therefore, the dissolved silica must be taken into account in any titration method for determining alkalin-

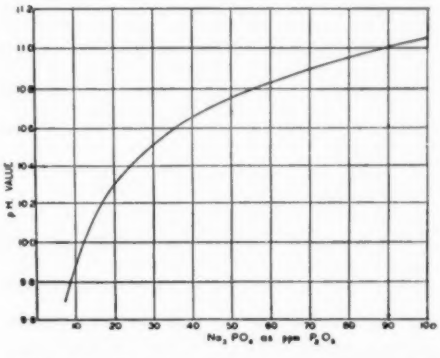

Fig. 2—pH value vs. concentration of trisodium phosphate

ities, unless some practicable means be found for eliminating it quantitatively, by precipitation or other method. The authors have not been able to find or devise any such means. It was found, however, from many synthetic solutions containing phosphate that the titration of metasilicate was reproducible quantitatively, 1 ml of $N/50$ acid being equivalent to 0.6 mg. SiO_2. A pH concentration curve for sodium metasilicate, expressed as ppm SiO_2, was constructed and found to have the same shape as the trisodium phosphate curve and to lie quite close to it when the latter was expressed as ppm P_2O_5 (Fig. 3).

From these considerations the authors have felt justified, for control-test purposes, in regarding sodium silicate present in boiler waters as an alkaline conditioning agent, on a par with other salts such as sodium phosphate. As such, the silicate is considered to be fully neutralized at Na_2SiO_3 just as phosphate is regarded as fully neutralized at Na_3PO_4. Any soda present in excess of the requirements of these two salts is regarded as free caustic soda and, conversely, any amount by which the soda falls short of the requirements of those two salts is regarded quantitatively as "soda deficiency," no attempt being made to allot this deficiency qualitatively to either of these salts. This conception enables a quantitatively reproducible method to be devised for the control of boiler water alkalinities, in place of the negative aspects of either vaguely including silicate with the "hydroxide alkalinity" or admitting that the results are unreliable because of interference from silica.

Phosphate and Silicate

From the two curves shown in Fig. 3 it appeared that quantitative use could be made of the additive effect of these two salts in determining alkalinities.

The small rises in the observed pH values, brought about by the substitutions, are in accordance with the difference between the two curves. Accordingly, a conversion graph, was constructed from the data in Fig. 3, to convert Na_2SiO_3 to equivalent amounts of Na_3PO_4 so far as the additive effect on pH value is concerned. When substitution was carried out quantitatively in accordance with this conversion graph the pH values obtained were the same as those of the original trisodium phosphate solutions, within the limit of error of the instrument. It is evident, therefore, that the degree of hydrolysis of either salt is not appreciably altered in the presence of the other, within the working range.

To ascertain the effect, if any, of the addition of Na_2HPO_4 to Na_2SiO_3 solutions, 150 ml of Na_2SiO_3 solution (containing 100 ppm SiO_2) was titrated with a Na_2HPO_4 solution (containing 374 ppm P_2O_5) and the pH values determined.

pH-Conversion Procedure

This information enabled a procedure to be devised by which the Purcell and Whirl pH-PO_4 coordinate method for boiler waters could be corrected for silicate. In the type of boiler waters mentioned, the amount of carbonate is negligible and it was found that the

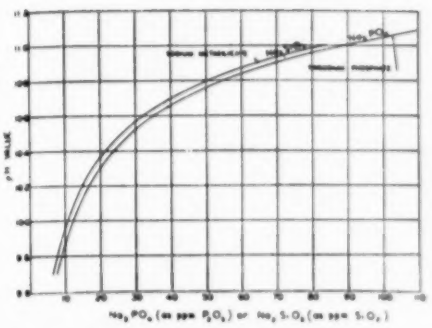

Fig. 3—pH concentration curves for Na_3PO_4 and Na_2SiO_3

organic matter present has no detectable effect on the pH value.

For this procedure the total phosphate is determined colorimetrically, in terms of P_2O_5. Silicate is also determined colorimetrically and converted to its equivalent in P_2O_5 by means of the curve in Fig. 4. These two amounts are then added and plotted against the determined pH value on Fig. 2. If the point falls on the curve all the phosphate is present as Na_2PO_4 and all the silicate is present as Na_2SiO_3. If the point falls below the curve then there is a "soda deficiency," quantitatively represented by the distance from the point to the curve along the *x*-axis, which is the measure of the amount of P_2O_5 effectively present as Na_2HPO_4. The "soda deficiency" is then calculated from the following equation

$$Na_2HPO_4 + NaOH \rightarrow Na_3PO_4 + H_2O$$

(For the purpose solely of facilitating calculation, all the silicate is considered to be present as Na_2SiO_3.)

The effectiveness of this procedure was verified by making up synthetic solutions representing boiler waters analyzed by this method. In every case the pH value of the synthetic solution was found to be within ±0.03 unit of the determined pH value of its corresponding boiler water.

If the point falls above the curve then free caustic soda is present, similarly represented by the horizontal distance from the point to the curve.

Titration Method

To obtain a method which could be carried right through by laboratory assistants, it was decided to investigate a titration procedure.

For the concentrations of phosphate employed the change points from Na_3PO_4 to Na_2HPO_4 and from Na_2HPO_4 to NaH_2PO_4 are, respectively, pH 8.6 and pH 5.4. A screened indicator had already been developed to give sharp end points at both pH values, using *N*/50 acid.

From Fig. 1 it will be seen that all the silicate is titrated at pH 6.5, but the indications are that most of it will be titrated at pH 8.6. This was, therefore, tried out on a solution of sodium metasilicate by noting the titers to pH 8.6 and from 8.6 to pH 5.4 (making due allowance for the small amount of carbonate present), the determinations being carried out in duplicate. The results showed that at the highest concentrations expected only 1 ppm of SiO_2 remained untitrated at pH 8.6 and it was considered justifiable to ignore this amount.

It can be taken, therefore, that the titration of boiler water to pH 8.6 ("A" titer) represents the Na_3PO_4 plus Na_2SiO_3 (plus NaOH, if any) and the titration from pH 8.6 to 5.4 ("B" titer) represents one-third of total phosphate, providing no other salts interfere.

From these titrations, plus the separate determination of silicate, the alkalinity relationships can be readily calculated. This was found to be the case with boiler waters free from organic matter, the results agreeing with the pH-conversion method to within ±5 ppm.

However, organic matter present in the boiler water produced a fading end point at pH 5.4, due to slow reaction with the acid. This type of organic matter had no measurable effect on the pH-conversion method. Further tests on boiler waters showed that none of the organic matter was titrated at pH 8.6 where a sharp end point was obtained, agreeing in every case with the Na_3PO_4 and Na_2SiO_3.

The titration to pH 5.4 was therefore discarded because all the information required could be obtained from the "A" titer and separate determinations of total phosphate and silicate and the pH value could be derived from these data and the Na_3PO_4 concentration curve (Fig. 2). In the titration to pH 8.6, using 100 ml of the boiler water and *N*/50 acid, 1 ml of acid is equivalent to 14.2 ppm P_2O_5 present as Na_3PO_4 or to 6 ppm SiO_2 present as Na_2SiO_3.

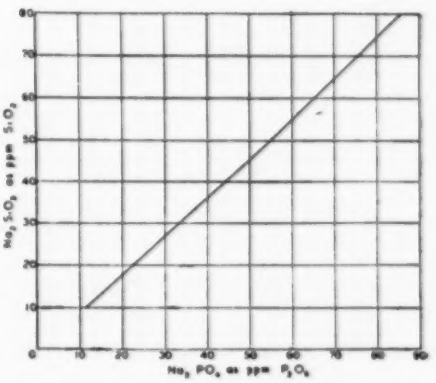

Fig. 4—Concentration conversion curve, $Na_3PO_4 \rightleftarrows Na_2SiO_3$, for the same pH value at 25 C

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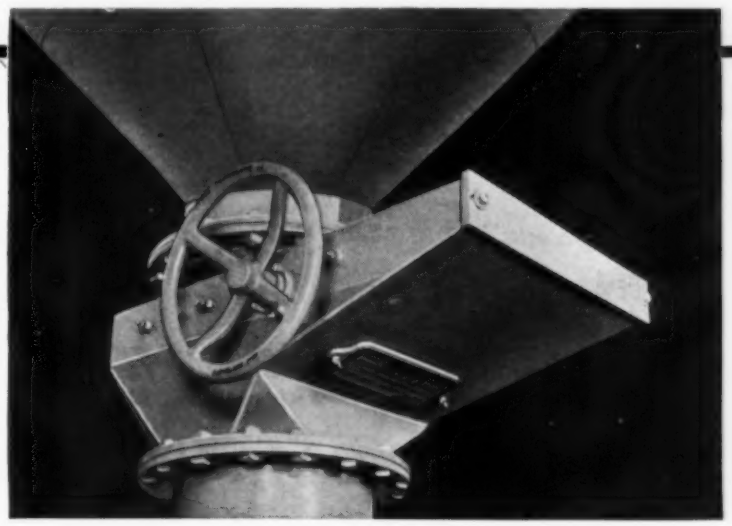

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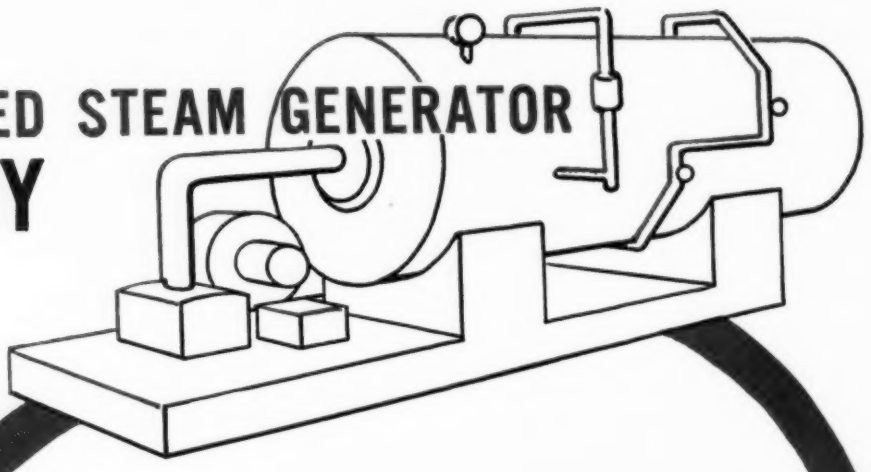

1

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Power Production in Sweden

According to data furnished by The American-Swedish News Exchange, the power output in Sweden has more than doubled since 1940; the supply is predominantly hydro; government-owned plants account for about 40 per cent of the total; private companies 55 per cent; and municipals about 5 per cent. A 600-mile transmission line to operate at 380,000 volts is now under construction.

PRODUCTION of electric energy in Sweden has expanded rapidly during the last twenty-five years, and especially during the last decade. In 1950, 18,300 million kilowatt-hours were produced, as compared with 16,140 million in 1949, 8600 million in 1940, and 3700 million in 1925. Water power resources which are economically available could produce annually 40,000 million kwhr, and it seems likely that they will have been exploited to the full in about twenty years.

Since Sweden lacks coal and oil it is only natural that the country should turn to its rivers and lakes for its energy needs, and thus it has become, in proportion to population, one of the world's leading producers of hydroelectric power. Per capita, the Swedish production of electricity is approximately the same as that of the United States, but while only about 30 per cent of the American output is based on water power, Sweden supplies 96 to 97 per cent of her requirements with hydroelectric power. Except for the island of Gotland, which lacks water power resources and so far has been supplied entirely by steam stations, and some industrial steam plants, steam power plants have been built mainly to meet emergencies. The importance of Sweden being able to satisfy her own energy needs to the greatest possible extent became especially evident during the Second World War, when coal imports were drastically reduced and shipments from England were completely cut off.

Longest Overhead Power Line, and First for 380,000 Volts

Most of the waterfalls are located in the northern part of the country with its very sparse population, while the heaviest consumption takes place in the South. To bridge this gap six 200,000-volt lines have been constructed, extending from Porjus in the far North. From Porjus there are also lines going out to Norwegian power stations at Narvik, and in the South the Swedish system is connected by submarine cables with Danish power plants.

The constantly growing demand for power, however, has given rise to a need for a transmission system with a higher capacity than the 200,000-volt lines. The State Power Board, which is building several large power stations in the North, in 1947 began construction of a line for alternating current at 380,000 volts, claimed to be the highest working voltage in the world. It will be completed in March of this year and covers a distance of 600 mi, from Harsprånget on the Lule River, 22 miles north of the Arctic Circle, to Hallsberg in central Sweden. At Hallsberg, the power will be stepped down to 200,000 volts and fed into the distribution network emanating from this station. A second line, extending over about 300 miles, is planned for completion in 1953, and the construction of a third line, from Hallsberg down to the country's southernmost province, has just been decided.

The new high-voltage transmission involves some unusual features, such as a double conductor line instead of the customary single line and the utilization of large series capacitors for reducing losses.

High-Voltage D-C Transmission

Research on the possibility of using high-voltage direct current for long-distance transmission also has led to important decisions. Alternating current cannot be used in submarine cables to the island of Gotland, which still depends on steam-generated power, but plans have been made for a high-tension d-c system for the transmission of hydroelectric power to this island in the Baltic. The project involves laying an underwater cable for 100,000 volts, 55 miles long, between the mainland and Gotland, and installing a station on each end converting 130,000 ac to 100,000 volts dc at the intake end and again to ac at the output end on the island. The cable will have only one conducting part, the return current being conducted through the sea water. Special tests have shown that this system will not harm fish or other sea life.

Both Public and Private Enterprise

In the North a number of power stations are under construction or being planned, and the largest is the Harsprånget plant, which is being constructed by the State Power Board. Like many of Sweden's power stations, the Harsprånget plant is built in the rock, an arrangement which provides greater resistance to air attacks and the advantage of an even temperature throughout the year. The powerhouse has been blasted out of the rock 225 feet underground.

Power supply in Sweden is administered by the goverment through an independent business concern, the State Power Board, by private companies, and by municipal authorities. The three groups cooperate to a great extent. The government is responsible for about 40 per cent of total production and distributes power over an extensive network, both to the railways and industrial concerns and to municipal distributing associations. About 5 per cent of the country's output is in the hands of municipal authorities, while private companies provide the remaining 55 per cent.

Practically all power stations in the country are coordinated and an exchange of power takes place on a large scale in accordance with schedules drawn up each

At a factory burning about 1500 tons of coal a month, silo storage is augmented by open storage of 4,400 tons on a small ground space alongside silo. Stockpile is handled by a ½ cu. yd. Sauerman Scraper as shown in the picture. The scraper was installed three years ago to replace a crane and bulldozer. The savings it has effected more than repay its original cost.

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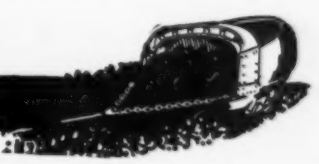

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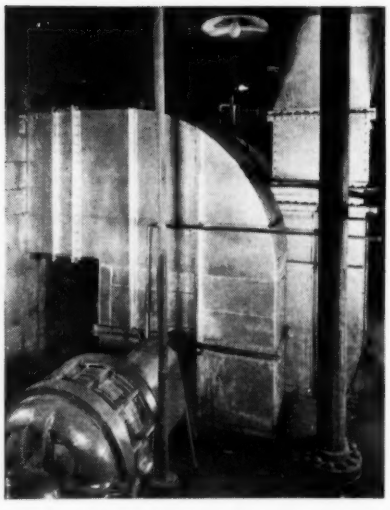

Twenty odd years ago, a new boiler was installed at the Calco Chemical Company's plant at Bound Brook, New Jersey. The induced draft and forced draft fans carried the 'Green' nameplate.

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Large Industries Consume 70 Per Cent of Electric Power

Industry is the largest consumer of electric power, accounting for about 70 per cent of total consumption. The railroads take 10 per cent, while 15 per cent is used by small industries and for household purposes, illumination, etc., in cities and other urban communities and 5 per cent is distributed in the rural districts.

The largest industrial users of electricity are the chemical industry, the ironworks and the pulp and woodworking industries, which together account for about three-fourths of the industrial consumption. As for the railroads, about 40 per cent of the total track mileage has been electrified, but since this includes all lines with heavy traffic, electricity is used for transportation up to a little more than 80 per cent of the total volume.

In the homes, electricity is being used to an increasing extent. Electric stoves, refrigerators, washing machines toasters and other household appliances have found their way into homes. About 93 per cent of the homes in the rural districts are supplied with electricity, and the rural electrification will probably be completed in a few years, the government offering considerable financial support for this purpose. In many rural districts power distribution is managed by cooperative associations, in which the consumers themselves are members. The associations are run by committees elected from the members, and the State Power Board offers them technical and economic advice free of charge. Neighboring associations frequently pool their skilled labor.

Huge Power Plant for Atomic Energy

Preliminary announcement has appeared in these columns and elsewhere of an agreement between the Government and a group of five utility companies in the Southwest, who have formed an organization designated as Electric Energy, Inc., whereby electricity for an atomic energy project near Paducah, Kentucky, will be supplied jointly by a new TVA steam station and one to be constructed by the utility group. Further details are now available.

The new plant of Electric Energy, Inc., which is being designed by Ebasco Services, Inc., will have an initial capacity of more than 650,000 kw in four units and will be of the outdoor type. Each of the boilers, which are being furnished by Combustion Engineering-Superheater, Inc., will supply steam at 2150 psi, 1000 F to a 163,000-kw reheat-type turbine-generator, and when operating at full capacity the plant will consume 150 carloads of coal per day.

Midwest Power Conference Program Announced

THE Thirteenth Annual Meeting of the Midwest Power Conference will be held on April 4 to 6, inclusive, at the Sherman Hotel, Chicago. Twenty-six technical and general interest sessions have been scheduled together with three luncheons and the "All Engineers' Dinner." As previously, the Conference is sponsored by the Illinois Institute of Technology in cooperation with nine midwestern colleges and universities and nine local and national engineering societies.

Those who attend the Conference will also have an opportunity to visit the Chicago Electrical Industry Show which will be held in the Sherman Hotel, April 3 to 6.

The preliminary program follows:

WEDNESDAY, APRIL 4

10:30 a.m. Opening Meeting. James D. Cunningham, presiding.

Address of Welcome, by Henry T. Heald, president, Illinois Institute of Technology.

Response for cooperating universities and societies, by L. G. Miller, Dean of Engineering, Michigan State College.

"The Engineer's Responsibility in the Fight Against the Disintegration of the Foundations of Freedom," by W. C. Mullendore, president, Southern California Edison Company.

"National Power Situation" by Walker L. Cisler, executive vice president, The Detroit Edison Co., Detroit.

12:15 p.m. Luncheon at College Inn sponsored by Chicago Section, A.S.M.E. Speaker: John T. Rettaliata, vice president and dean of engineering, Illinois Institute of Technology, on "Jet Propulsion."

2:00 p.m. Session on "Large Steam Generators."

"Spreader Stokers for Large Boilers," by J. S. Bennett, vice president, American Engineering Co., Philadelphia.

"The Trend Toward Reheat," by H. G. Ebdon, vice president, Combustion Engineering-Superheater, Inc., New York.

2:00 p.m. Session on "Water Supply and Conservation," sponsored and arranged by the National Association of Power Engineers.

"The Ground-Water Resources of the Midwest," by Frank C. Foley, District Geologist, U. S. Department of the Interior.

"Conservation of Water" by Raymond C. Kelly, president, Cooling Tower Institute.

2:00 p.m. Session on "Power Transmission at High Voltage."

"High Voltage Transmission," by S. B. Crary, General Electric Co., Schenectady, N. Y.

"Extra High Voltage Transmission," by H. P. St. Clair, American Gas & Electric Service Corp.

3:30 p.m. "Ridgeland Station—A Step Forward in Power Generation," sponsored and arranged by Power and Fuels Division, Chicago Section, A.S.M.E.

"Mechanical Design and Construction," by H. C. Schroeder, partner, Sargent & Lundy.

"Electrical Design and Construction," by John C. Woods, station design engineer, Commonwealth Edison Co., Chicago.

"Operating Experiences," by Ralph B. Gutekunst, chief engineer, Ridgeland Station, Commonwealth Edison Co.

3:30 p.m. "Industrial Systems" (Electrical Session), arranged and sponsored by Industrial Group, Chicago Section, A.I.E.E.

"Motor Speed Control on A-C Power Systems," by E. W. Seeger, vice president in charge of development, Cutler-Hammer, Inc.

"Grounding of Industrial Systems," by W. C. Bloomquist, General Electric Co.

THURSDAY, APRIL 5

9:00 a.m.–12:00 noon Water Technology Session No. 1—"Symposium on Organic Water Treatment Materials," sponsored by Joint Research Committee on Boiler Feedwater Studies.

"The Development of Organics for Water Treatment," by J. A. Holmes, vice president, National Aluminate Corp.

"Organic Agents in Boiler Scale and Sludge Control," by John J. Maguire, Technical Division, W. H. and L. D. Betz, Philadelphia.

"Organic Synergists in Foam Control," by C. M. Bodach, chief chemist, and L. O. Gunderson, assistant vice president, Dearborn Chemical Co.

"Use and Misuse of Organic Water Conditioning Materials," by Robert W. Liddell and Louis C. Bishop, Hall Laboratories, Inc.

9:00 a.m. Session on "Electronics in Power Systems," sponsored and arranged by Electronics Group, Chicago Section, A.I.E.E.

"Microwaves for Relaying, Control and Communication," by A. W. Adams, Bonneville Power Administration.

"Factors in the Choice of Microwave or Carrier Current for Power System Operation and Dispatching," by F. C. Krings, General Electric Co.

9:00 a.m. Session on "Fuels and Combustion."

"A Method of Estimating the Ultimate Analysis of Bituminous Coals from the Proximate Analysis," by Edward W. Jerger and John R. May, Iowa State College.

"Operating Experiences with Combination Blast Furnace Gas, Coke Braize, and Oil Fired Boiler at Wisconsin Steel," by C. D. Northam and John T. Harvey, Wisconsin Steel Works, International Harvester Co.

10:30 a.m. Session on "Fly Ash."

"Coal Industry Findings on Fly Ash" by Elmer W. Kaiser, Bituminous Coal Research, Inc.

"Practical and Workable Air Pollution Control Ordinances," by Joseph C. McCabe, Associate Editor, *Power*.

10:30 a.m. Session on "System Control and Operation," sponsored by Chicago Section, A.I.E.E.

"A High-Speed Load-Frequency Control System," by T. L. Mell, Brown Instrument Division, Minneapolis-Honeywell Regulator Co.

"Excitation Control," by M. Temoshok, General Electric Co.

"Electronic Excitation," by J. E. Barkle and D. F. Schankle, Westinghouse Electric Corp.

12:15 p.m. Luncheon at College Inn, sponsored by Chicago Section, A.I.E.E. Speaker: Jack T. Wilson, Chief Physicist, Allis-Chalmers Manufacturing Co., on "What Can the Engineer Contribute to Better Living?"

2:00 p.m. Session on "Soot Removal and Minimizing Fireside Deposits."

"Retractable Soot Blowers in Central Station Boilers—Comparison of Air and Steam Blowing," by D. E. Hibbner, vice president, Vulcan Soot Blower Division, Continental Foundry and Machine Co.

"Minimizing Fireside Deposits by Humidification of Combustion Air," by Paul Murphy, Jr., and John D. Piper, The Detroit Edison Co.

2:00 p.m. Session on "Hydro Power."

"The Tennessee Valley Authority Hydroelectric Program", by Harry Wiersema, assistant to the chief engineer, Tennessee Valley Authority.

"Problems in Power Plant Design for Reclamation Multiple-Purpose Projects," by I. A. Winter, Bureau of Reclamation, Denver.

2:00 p.m. Session on "The Heat Pump."

"Influence of Freezing on Heat Pump Ground Coil Capacity," by A. D. Kafadar and I. B. Fieldhouse, Armour Research Foundation, and R. A. Budenholzer, Illinois Institute of Technology.

3:30 p.m. Session on "Power Generation Equipment."

"Balancing Large Turbine-Generator Rotors," by P. R. Heller and C. H. Janthey, Westinghouse Electric Corp.

"Pumped Storage Hydro-Electric Power," by William J. Rheingans, Frank Jaski and H. H. Roth, Allis-Chalmers Manufacturing Co.

"Instrumentation and Control for Small Power Plants" by P. S. Dickey, Bailey Meter Co.

3:30 p.m. Session on "Small Power Plants."

"New Materials and Construction Methods for Small Power Plants," by C. Maxwell Stanley, partner, Stanley Engineering Corporation, Muscatine, Ia.

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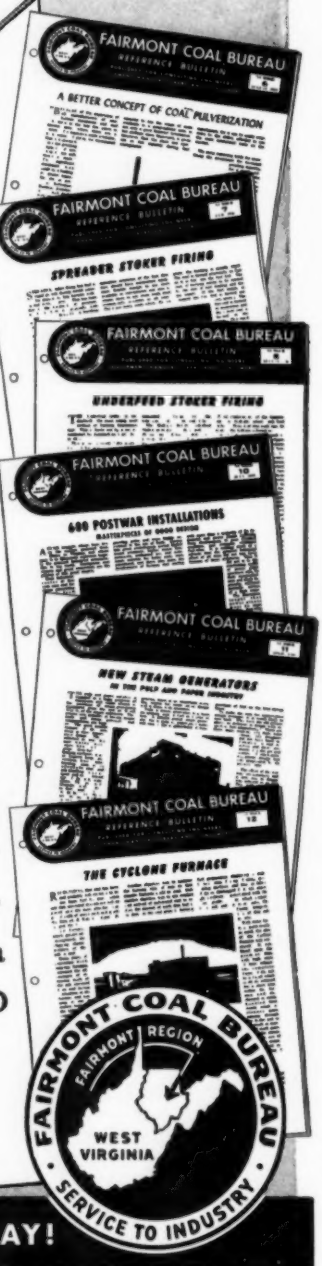

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3:30 p.m. Session on "Residential Applications of Electric Power Heating and Hot-Water Supply."

"Load Characteristics and Economics of Electric House Heating," by W. F. Friend, Ebasco Services, Inc., New York.

6:30 p.m. All Engineers Dinner.

FRIDAY, APRIL 6

9:00 a.m. Session on "Power System Grounding."

"Trends in Power System Grounding," by E. T. B. Gross, Illinois Institute of Technology.

"The Delta-Grounded Transformer Development and Application," by H. L. Hoeppner, Pioneer Service and Engineering Co.

9:00 a.m. Water Technology Session No 2—"Ion Exchange," Sponsored and arranged by Water Technology Division, Chicago Section, A.S.M.E.

"Experience with Silica Removal Demineralizer Plants," by S. B. Applebaum, Cochrane Corporation, Philadelphia.

"Boiler Feedwater Treatment for a High-Pressure, High-Makeup Power and Steam Producing Plant," by V. J. Calise, technical director, Graver Water Conditioning Co.; J. Harlow, chief mechanical engineer, and H. Farmer, chief chemist, Philadelphia Electric Co.; and H. Lane, chief chemist, Graver Water Conditioning Co.

9:00 a.m. "Diesel Engines and Gas Turbines for the Production of Power."

"Use of Diesel Generating Units on the Northern States Power Company System," by E. F. Carlson and H. H. Rhoades, Northern States Power Co.

"Power Generation by Gas Turbines," by A. G. Mellor, General Electric Co.

10:30 a.m. General Session on "Atomic Energy for Power Generation."

"Atomic Energy—A Review of Fundamentals," by Frank H. Spedding, Iowa State College.

"Atomic Energy and the Power Industry," by George G. Brown, Atomic Energy Commission.

12:15 p.m. Midwest Power Conference Luncheon, sponsored by Chicago Section W.S.E. Speaker: John Slezak, President, Turner Brass Co., on "The Engineering Mind in Business."

2:00 p.m.–5:00 p.m. "Progress in Gas Turbine Locomotive Development."

"Progress Report on the Coal-Burning Gas Turbine," by J. I. Yellott, Locomotive Development Committee, and F. D. Buckley, Locomotive Development Committee Project, American Locomotive Co.

"Progress Report on Gas-Turbine Electric Locomotive" by Allen Howard, General Electric Co.

"Progress Report on the Baldwin-Westinghouse Gas-Turbine Electric Locomotive" by T. J. Putz, Westinghouse Electric Corp.

"Locomotive Gas-Turbine Unit" by W. B. Tucker, Allis-Chalmers Mfg. Co.

2:00 p.m. Water Technology Session No. 3—"Cooling Tower Problems."

"Recent Studies in Cooling Tower Wood Deterioration," by D. R. Baker, The Marley Co., Kansas City, Kans.

"Equipment for Treatment of Makeup of Cooling Towers," by Durando Miller, The Permutit Co., New York.

2:00 p.m. "Power System Apparatus," sponsored and arranged by Power Group, Chicago Section, A.I.E.E.

"Power Transformer Acceptance Tests," by Byron Evans, U. S. Bureau of Reclamation.

"New Developments in Lightning Arrester Design," by J. H. Kalb, Ohio Brass Co.

3:30 p.m. Water Technology Session No. 4—"Special Problems."

"Meeting the Soda Ash Shortage by Conversion of Filters to Zeolite Softeners," by George H. Krapf, Carnegie Illinois Steel Corp.

"Feedwater Treatment in the Packing Plant," by M. B. Golber, Armour & Co.

3:30 p.m. "Power Stations."

"Power Plant Communication," by William Jarzembski, Panellit, Inc., Chicago.

"Lighting for Steam Power Plants," by S. L. Chapin, Sargent & Lundy, Chicago.

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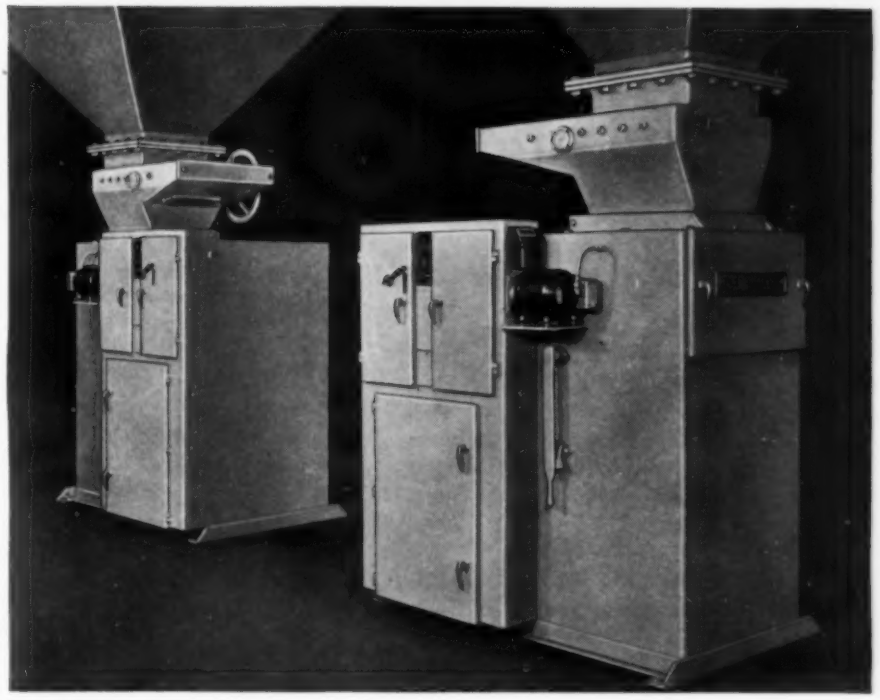

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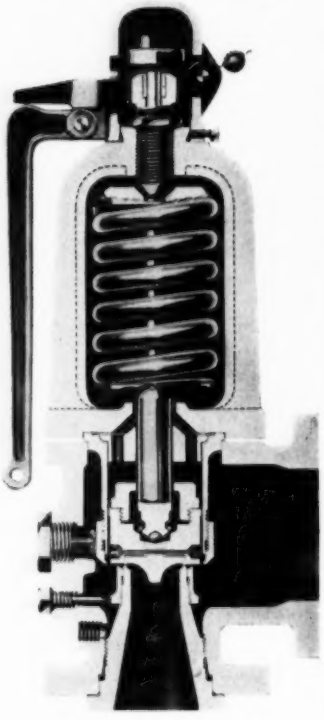

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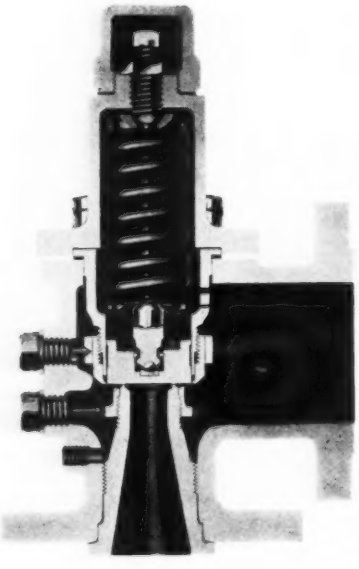

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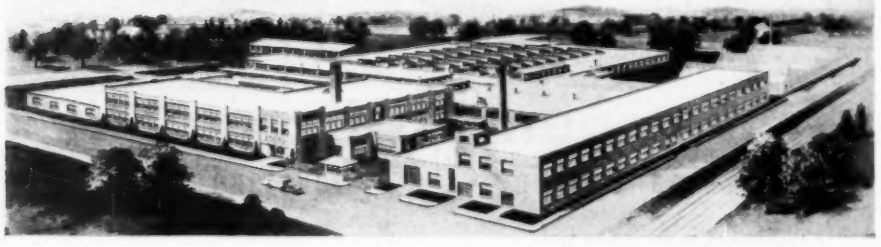


ASME Spring

ATLANTA, Ga., will be the scene of the 1951 ASME Spring Meeting, which is scheduled for April 2–5 with headquarters at the Atlanta Biltmore Hotel. In addition to a technical program covering such fields as power, fuels, production engineering, machine design, wood industries, textiles and management, there will be a number of interesting inspection trips and social events. Among the plants to be visited are the General Motors assembly plant at Chamblee, Ga., the Southern Wood Preserving Co., and the Atlantic Steel Co. The following is a portion of the general program that is of particular concern to those in the power field:

Monday, April 2, 9:30 a.m.

"Multi-fuel Burners, Their Application and Design," by W. H. Decker, Sinclair Refining Co.

"The Use of Oil and Gas in Stoker-Equipped Furnaces," by J. A. Hayes, Combustion Equipment Div., Todd Shipyards Corp.

"Economic Factors in the Design of Cooling Towers," by A. R. Le Bailly, Sargent & Lundy.

"Comments on Cooling-Tower Economics," by Louis Elliott, Ebasco Services, Inc.

"Selection, Operation and Maintenance of Industrial Cooling Equipment (Cooling Towers and Air-Cooled Exchangers)," by Howard E. Degler, The Marley Co., Inc.

"Recirculation in Cooling Towers," by Joseph Lichtenstein, Foster Wheeler Corp.

Monday, April 2, 12:15 p.m.

President's Luncheon

"Engineering Manpower Developments," by J. Calvin Brown, President of A.S.M.E.

Monday, April 2, 2:30 p.m.

"Power from Wood Waste," by E. A. Carsey, Kirk & Blum Mfg. Co., W. H. Kuhn, Fairfield Engineering Co., and D. Gusler, Bassett Furniture Industries, Inc.

"Developments in Spreader Stoker Firing of Wet Wood," by A. S. Weigel, Combustion Engineering-Superheater, Inc., and J. A. Freiday, Ebasco Services, Inc.

"Operating Experiences with Cooling Towers in the Central Gulf Area," by H. G. Hiebeler, Houston Lighting and Power Co.

"Problems Relating to the Operation, Maintenance, and Chemical Control of Forced and Induced Draft Cooling Towers for Steam Electric Generating Stations," by V. F. Estcourt, Pacific Gas and Electric Co.

"Deterioration of Wood in Cooling Towers," by R. H. Baechler and C. A. Richards, Forest Products Laboratory.

Meeting Program

Monday, April 2, 5:00 p.m.

Roy V. Wright Lecture by Frank H. Neely, Sixth District Federal Reserve Bank.

Tuesday, April 3, 9:30 a.m.

"Current Operating Results and Developments in Mercury-Steam Power Plants, 1949–1950," by Harold N. Hackett, General Electric Co.

"Mercury Boiler Treatment with Titanium and Magnesium Metal," by Richard C. Reid, General Electric Co.

"Natural Steam Power Plants in Italy," by Giuseppe Donata, E. Marelli & Co.

"The Mechanism of Wood Preservation and Wood Preserving Plants" by J. Alvin Vaughan, Southern Wood Preserving Co.

"A Current Plan for Young Engineers," Junior Conference led by E. W. O'Brien, W. R. C. Smith Publishing Co.

Wednesday, April 4, 9:30 a.m.

"Effect of Taper on Screw Thread Load Distribution," by E. E. Stoeckly, General Electric Co., and H. J. Macke, Harvard University.

"The Steam Generating Station as a Source and Sink for the Heat Pump," by J. A. Eibling and B. A. Landry, Battelle Memorial Institute.

"Fuel Availability and Its Influence on Boilers and Burning Equipment," by P. R. Loughin, Babcock & Wilcox Co.

"Determination of the Effective Strained Length of Standard Stud Bolts" by Robert S. Sherwood, Iowa State College, and Richard C. Dove, University of New Mexico.

Wednesday, April 4, 12:15 p.m.

"The Importance of Southern Industry to the National Economy," by F. F. Groseclose, Georgia Institute of Technology.

Wednesday, April 4, 2:30 p.m.

"Finding the Why of Accidents," panel discussion in collaboration with the American Society of Safety Engineers.

"The Role of the Engineer in Area Development," by L. J. Hughlett, Arthur D. Little Co., Inc.

Wednesday, April 4, 7:00 p.m., Banquet

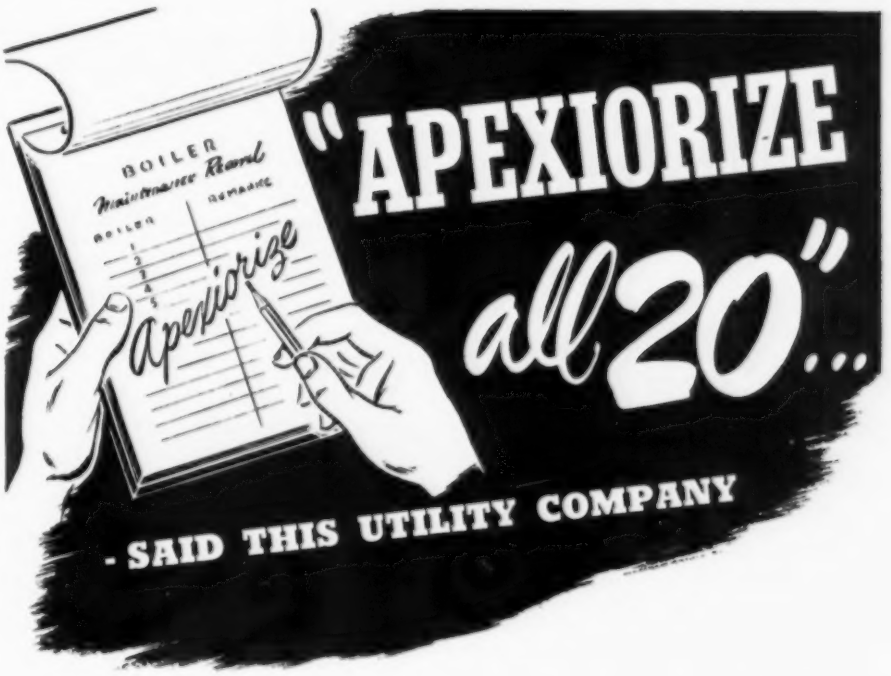
Speaker: W. H. Ruffin, president, National Association of Manufacturers.

Thursday, April 5, 9:30 a.m.

"Economics of Materials Handling" by John B. Day, Georgia Institute of Technology.

"Application of Conveyors to Coal Mining Operations," by G. B. Maples, Continental Gin Co.

"The Application of Statistical Techniques in Time Study" by George Wilkinson, Paul B. Mulligan and Co.



And with the project already half completed, this company's central station steam-generating units will soon be internally protected with Apexior Number 1 surfacing.

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Basically, though, there's just one reason for Apexiorizing any boiler and that is to build into it an operating factor of safety not otherwise obtainable. With Apexior guarding internal surfaces, an expendable maintenance item — not costly metal — becomes your first line of defense. Should operating conditions deviate for any reason from the ideal, Apexior takes the consequences while steel, safely isolated, retains all of its initial strength and soundness.

Apexiorizing is a simple, inexpensive way to make a good boiler better — something we've been specializing in now for thirty-three years. Our 8-page Bulletin 1530 gives you all the facts — and if you'll give us the necessary data on your boilers when you write (number and size of tubes and drums), we'll be happy to include a quotation.

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REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Mechanical Engineers' Handbook

Lionel S. Marks, Editor

This new Fifth Edition of the well-known "Mark's Mechanical Engineers' Handbook" represents a complete revision in which more than a hundred engineers, each a recognized authority in his special field, have cooperated to produce a 2236-page volume of carefully selected data on every branch of mechanical engineering.

Significant recent developments discussed under the heading of "Theory" are fluid mechanics, stresses in turbine disks, transonic and supersonic aerodynamics, aircraft jet propulsion, rockets and television. Under "Processes" the text takes up radiant or panel heating, solar heating, high-vacuum pumps, industrial supersonics, modern casting methods, statistical quality control and automatic process control.

Furnished also is new or greatly revised information on the materials of engineering, such as ferrous and non-ferrous alloys, super-alloys for highest temperatures, plastics, elastomers, silicones, adhesives, rocket fuels, reflective heat insulation and powder metallurgy. Power costs are analyzed in the light of current conditions, as are gas turbines and atomic energy as power sources.

The sixteen sections that make up the text are: Mathematical Tables and Weights and Measures; Mathematics; Mechanics of Solids and Liquids; Heat; Strength of Materials; Materials of Engineering; Fuels and Furnaces; Machine Elements; Power Generation; Hoisting and Conveying; Transportation; Building Construction and Equipment; Machine-shop Practice; Pumps and Compressors; Electrical Engineering; Engineering Measurements, Mechanical Refrigeration, etc.

A completely cross-referenced index of more than 12,000 entries and a new, enlarged format, thumb-indexed, are designed to meet the daily needs of engineers who need facts at their finger tips.

The page size of this edition has been increased to 6 by 9 in. and the price is $15.

Fuels and Combustion Handbook

Allen J. Johnson, Editor
George H. Auth, Associate Editor

The objective of this practical handbook is to bring together for ready reference representative factual material on fuels and combustion. Much of this information heretofore had to be searched for in pamphlets and articles scattered throughout the trade press and in publications of government bureaus and engineering societies.

More than 450 major references were used by the editors in compiling the handbook. It is estimated that 50 per cent of the material is less than five years old and over 80 per cent less than ten years old. The scope is sufficiently broad to interest fuel technicians, engineers and operating men.

The handbook is characterized by an usually large number of tables of data and by the extensive use of alignment charts for rapid computations. The nomograph method of computing heat balances has been presented in quite some detail.

There are eight sections in the handbook, covering solid fuels, liquid and gaseous fuels, combustion, fuel selection, coal preparation, fuel-handling methods, heat transfer and steam generation, and test procedures. Many recent developments in the broad field of combustion are discussed, including those associated with synthetic fuels, the heat pump, gas turbines, and spreader stokers. One very interesting chapter is entitled "Factors Involved in the Selection and Purchase of Fuel."

Allen J. Johnson, editor of the handbook, is a consulting mechanical engineer who for many years was director of the Anthracite Institute Laboratory. The associate editor, George H. Auth, is professor of mechanical engineering at Villanova College.

The handbook is made up of 915 pages and sells for $12.50.

Sourcebook on Atomic Energy

By Samuel Glasstone

Following a request of the American Textbook Publishers Institute for a comprehensive sourcebook on atomic energy this book was prepared by Dr. Samuel Glasstone at the instance of the Atomic Energy Commission. It brings together important facts about the past history, present status and possible future of atomic science. While the work has been termed a "primer" on the whole subject of atomic science, the very complexity of the topics under discussion makes for some difficulty in reading and comprehension. On the whole it is written in language as simple as is compatible with the subject.

Throughout the book a historical approach is used wherever possible to describe the growth of thought and knowledge in the atomic field. Some mathematical expressions have been found necessary to explain certain atomic developments, but most of the equations are intelligible to those with a knowledge of algebra.

An idea of the scope of the book may be had from the following representative chapter titles: Constituents of the Atom, Natural Radioactivity, Nuclear Radiations, Isotopes, Nuclear Transmutation and Artificial Radioactivity, The Neutron, Nuclear Fission, The Utilization of Nuclear Energy, The Uses of Isotopes, Cosmic Rays and Mesons, and Radiation Protection and Health Physics.

The book is printed in double-column form, and each paragraph is numbered for convenient reference. There are more than 300,000 words in the 546-page hard-bound volume which sells for $2.90.

Modern Refractory Practice

Prepared by Harbison-Walker Refractories Co.

The Third Edition of this publication is a combination of a practical engineering handbook, a technical treatise, and a catalog of the company's products. Scale drawings of twenty types of specialized furnaces which illustrate current industrial practice make up an interesting section of the book The drawings show in detail design of furnaces, types of refractories generally used and, in some cases, alternate types for special conditions of operation.

A chapter is devoted to suggestions of a practical nature regarding the selection, care and use of refractories, including handling, installation and service factors affecting the life of refractories. Boiler settings are discussed briefly, and recommendations are made for suitable refractories for furnaces fired by coal, gas, oil, wood and bagasse.

Properties of refractories are the subject of an important chapter which covers mineralogy, stability relations at high temperatures, and physical and chemical properties pertaining to the utility of refractories.

The book contains much information not previously published and may be used as a text in connection with courses in ceramics, metallurgy or chemical engineering. Priced for general distribution at $6, the 440-page volume may be obtained from the Harbison-Walker Refractories Co., Farmers Bank Building, Pittsburgh 22, Pa.

Code for Pressure Piping

To bring this 1951 ASME Code in line with current practice most of the text of the 1942 edition has been revised and new material added, including a number of specifications and tables of allowable stresses covering new materials. Welding rules are provided along with examples to show their application. Following are the contents: Power Piping Systems; Gas and Air Piping Systems; Oil Piping Systems; District Heating Piping Systems; Refrigeration Piping Systems; Fabrication of Pipe Hangers, Supports, Anchors, Sway Bracings, Vibration Dampeners, and Pipe Joints Other Than Welded; Expansion and Flexibility Provisions; Welding of Pipe Joints; Welded Branch Connections and Fabricated or Cast Specials; Materials—Their Specifications and Identification; Appendices.

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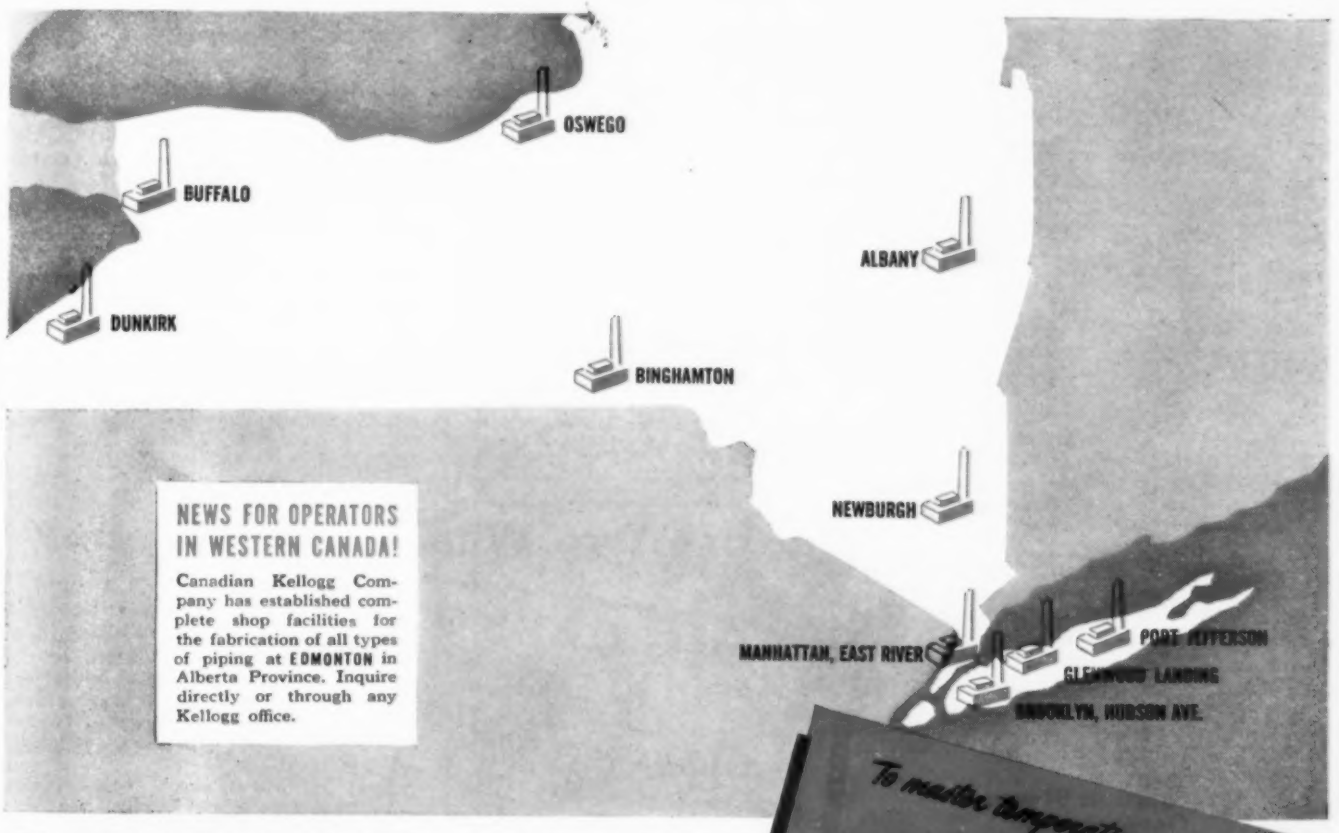

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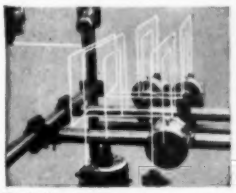

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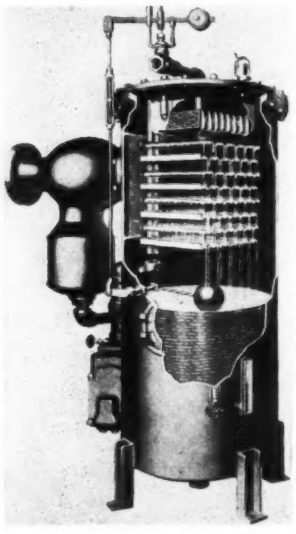
NEW EQUIPMENT

Feedwater Heater

The Swartwout Junior Feedwater Heater, made by The Swartwout Co., Cleveland, Ohio, is designed specifically for small manufacturing plants, institutions, public buildings, dairies, laundries and greenhouses with boiler capacities of 300 hp or less. Made of fabricated steel,



the heater has specially designed stainless steel trays which disperse feedwater over a large area in the form of thin curtains, thereby aiding in heat transfer. Ample water storage space is provided, eliminating the necessity for a sump or hot well.

Recirculation Steam Generator

A compact, reliable steam plant culminating a five-year period of research, development and operating experience is now being offered by Combustion Engineering-Superheater, Inc., New York. Known as the "C-E Re-circulation Steam Generator," it is actually a complete steam plant which includes feed pump, fuel-burning equipment, combustion and other controls, forced-draft fan, safety valves, circulating pump and all other auxiliaries. It may be fired by light or heavy fuel oil or by natural gas, and is available in several sizes for steam capacities from 2800 to 6000 lb per hr and for pressures up to 300 psig.

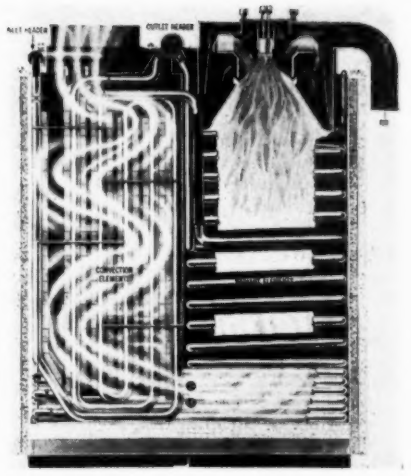
Such a unit was originally developed for train heating service, in connection with diesel-electric locomotives where drastic limitations exist as to weight, space and power requirements for steam generation. At present over 200 are in service on major American railroads.

Following successful use for train heating, the possibilities of the generator for the industrial and institutional fields were investigated, and led to initial applications early in 1950. Since then a number of generators have been installed for such services as space heating; processing of tobacco, chemicals, cotton fabric, asphalt, dairy products, paper products, rubber vulcanizing, space heating in central stations, etc.

Notable features of the generator are its compactness and the fact that it employs controlled recirculation. The 6000-lb capacity unit for burning light oil or gas occupies a space 6 ft 11 in. long × 5 ft 5 in. wide × 6 ft 11 in. high, and the heavy oil burning unit is only slightly larger.

The principal parts comprise the heating elements, operating motor, feed pump, feedwater regulator, circulating pump, burner, fuel oil pump and air blower. The heating surface consists of a number of radiant and convection elements within a paneled steel casing. Each element is connected both to the inlet header and the outlet header. An orifice at the inlet end controls the flow of water to the element.

The outlet header is connected with a vertical drum called a separator, the top



part of which has a circular passage for the steam and water coming from the outlet header at high velocity. The centrifugal force throws the water to the outside of the passage, where it is carried to a vertical passage leading to the lower part of the drum and to the circulating pump. The steam is separated from the water and flows to the outside steam line. The circulating pump forces water at a velocity above the rate at which scale forms into the inlet header and then through the heating elements to the outlet header.

Two burners are provided to give maximum combustion flexibility. For starting,

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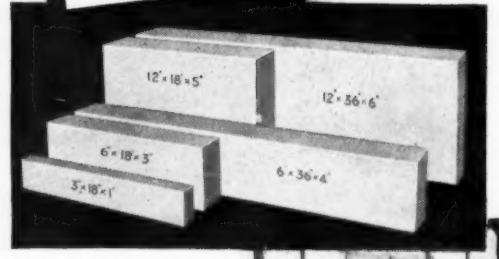

R & I Block is available in standard sizes from 1" to 12" thick — also in special sizes and as curved block.

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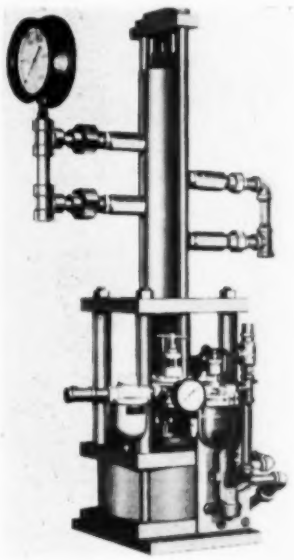
a small "all-on" or "all-off" electrically ignited burner is operated by a pressure-limit switch. It is limited to a steam demand of 700 lb per hr, after which a larger burner is cut in and operated up to maximum rating. At medium and heavier loads both burners are in operation. Fuel oil and air to the larger burner are adjusted by the combustion control in accordance with load demands. The arrangement may be varied slightly to burn heavy fuel oil or gas.

Air for combustion is supplied by a blower and regulated by a damper that is controlled by the pressure of fuel oil, and the fuel oil pressure, in turn, is controlled by the steam pressure.

The feed pump, which is automatically controlled by a float system in the separator drum, pumps the feedwater to a closed heat exchanger where it is preheated by the heat of its exhaust steam. The preheated feedwater then enters the outlet header and the steam separator, where it is deaerated.

Hydro-Pneumatic Pump

The Aldrich Pump Co., Allentown, Pa., has completed design improvements on the Aldrich-Lytle hydro-pneumatic unit. This pump is self-contained, uses normal plant air as the power medium and pro-



vides pressures up to 20,000 psi at small volume. It may be used to operate small molding presses and to test tubing, valves and pressure vessels.

Dry-Type Transformers

Hermetically sealed dry-type transformers with Class B insulation have been made available by the Transformer and Allied Product Divisions of the General Electric Co. in ratings up through 1500 kva and 15,000 volts. Since they are nitrogen filled, the units may be installed indoors without the expense of fireproof vaults normally required for oil-filled units. They can also be installed outdoors, where there is no exposure to lightning, or underground.

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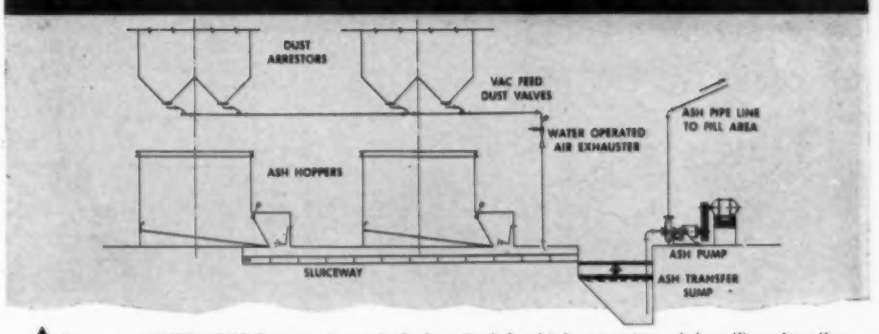

A Beaumont HYDRAULIC System is particularly suited for high capacity ash-handling; handles wet ash or dry, molten slag and large clinkers; fits any type of power plant arrangement; is completely enclosed, preventing dust or gas from escaping to the boiler room; and can be operated by one man on a part time basis.

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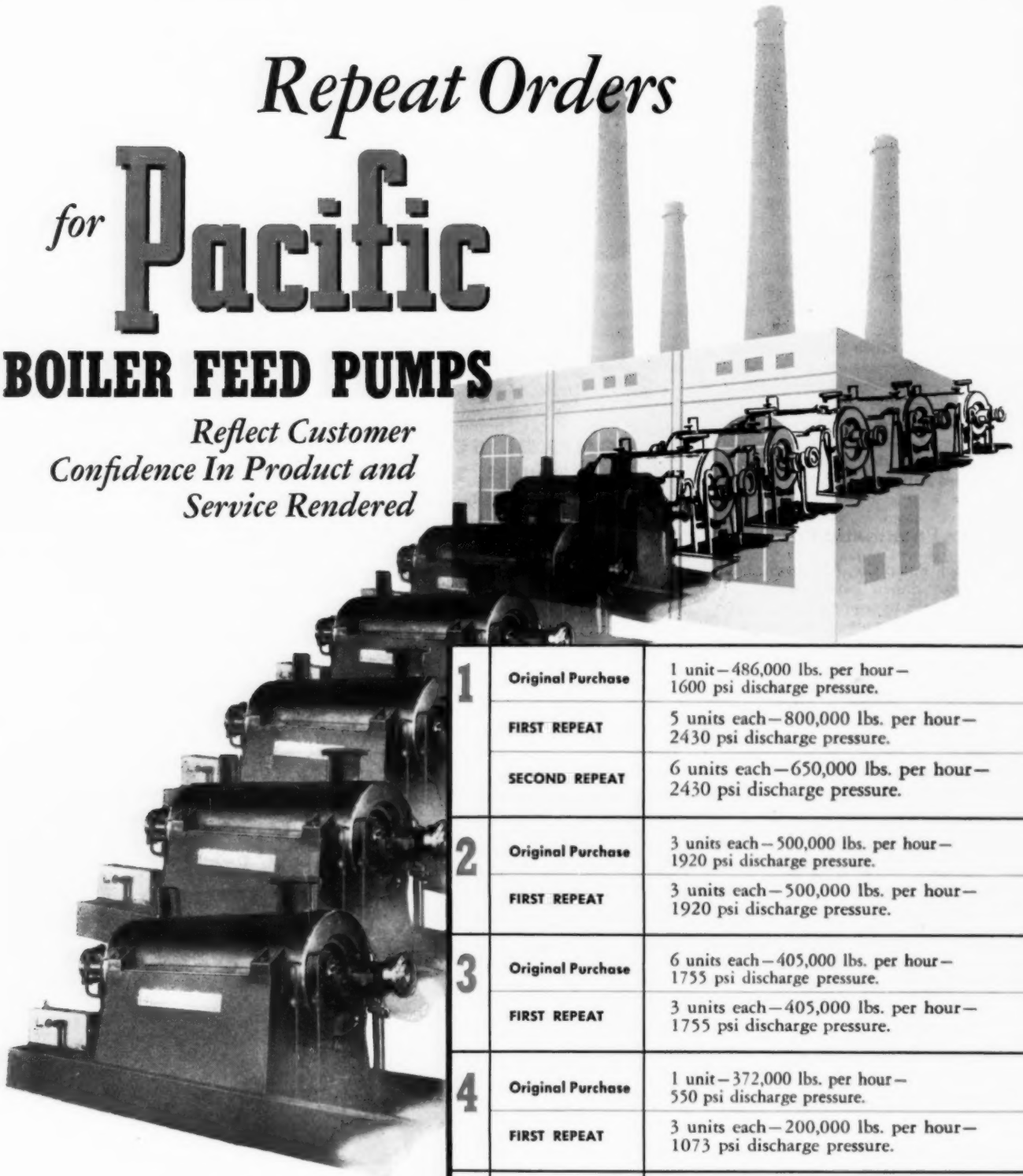

1	Original Purchase	1 unit—486,000 lbs. per hour—1600 psi discharge pressure.
	FIRST REPEAT	5 units each—800,000 lbs. per hour—2430 psi discharge pressure.
	SECOND REPEAT	6 units each—650,000 lbs. per hour—2430 psi discharge pressure.
2	Original Purchase	3 units each—500,000 lbs. per hour—1920 psi discharge pressure.
	FIRST REPEAT	3 units each—500,000 lbs. per hour—1920 psi discharge pressure.
3	Original Purchase	6 units each—405,000 lbs. per hour—1755 psi discharge pressure.
	FIRST REPEAT	3 units each—405,000 lbs. per hour—1755 psi discharge pressure.
4	Original Purchase	1 unit—372,000 lbs. per hour—550 psi discharge pressure.
	FIRST REPEAT	3 units each—200,000 lbs. per hour—1073 psi discharge pressure.
5	Original Purchase	6 units each—95,000 lbs. per hour—600 psi discharge pressure.
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